Metal Concentrations in Soils and Produce from Gardens in Flin Flon, Manitoba, 2002

By Geoff Jones and Vicki Henderson

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Geoff Jones
Habitat Management and Ecosystem Monitoring Section
Wildlife and Ecosystem Protection Branch
Manitoba Conservation

Vicki Henderson
Habitat Management and Ecosystem Monitoring Section
Wildlife and Ecosystem Protection Branch
Manitoba Conservation

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EXECUTIVE SUMMARY

This study was conducted in 2002 to determine the concentration of metals and other elements in garden soils and vegetable crops grown in the city of Flin Flon, Manitoba, and provide an assessment of the health risk associated with consuming the vegetables. The same cultivars of lettuce, beans, carrots, potatoes, and tomatoes were planted in nine gardens in Flin Flon, one garden in Cranberry Portage, and one garden in The Pas. Replicate soil and vegetable samples were collected from each garden during August and September and analyzed for total concentrations of selected metals and other elements.

Soil concentrations of arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg), selenium (Se), and zinc (Zn) were highly correlated with each other and were significantly elevated at most gardens in Flin Flon relative to the garden in The Pas. In some cases the concentrations of these elements in the Flin Flon gardens exceeded established soil quality guideline levels, while concentrations in the soil from the gardens in Cranberry Portage and The Pas did not exceed the guidelines. Arsenic, Cd, Cu, Pb, Hg, and Zn are known constituents in past and present atmospheric emissions from the Hudson Bay Mining and Smelting (HBM&S) smelter in Flin Flon.

Concentrations of As, Cd, Cu, Pb, Hg, Se, and Zn in vegetables varied between sites and between vegetable species. In the majority of cases, vegetables grown in Flin Flon had higher concentrations of these metals than vegetables grown in The Pas. Lettuce tended to accumulate the highest concentrations of metals, followed by carrots and potatoes, beans, and tomatoes. Concentrations of some elements in vegetable samples were often highly correlated with soil concentrations. For example, Hg and Cd concentrations in washed lettuce, potato, and carrot samples were highly correlated with concentrations in the soil ($r > 0.7$), suggesting that these vegetables absorbed the metals from the soil. Comparisons between unwashed and washed samples of lettuce indicated that atmospheric deposition of the As, Cu, Zn, Pb, and, to perhaps a lesser degree, Hg had occurred during the 2002 growing season. The exact source of these metals is not known, but is likely a combination of deposition from smelter emissions, dust from the tailings impoundment, and dust and particles from the surrounding soil.

Tolerable daily intake (TDI) guidelines from a number of sources were used to assess the health risk associated with intake of elements through eating vegetables grown in the gardens in this study. In most cases the consumption amounts required to exceed the TDI levels were well above the expected daily intake of each vegetable. Tolerable daily intake levels are based on consumption over the long-term.

while private garden vegetables, particularly lettuce, are primarily consumed only during the two to three month growing season. In addition, vegetables from private gardens usually make up only a small portion of the daily diet and consumption by the most vulnerable individuals (toddlers and children) is usually low. Based on these facts, it was concluded that there is a very low risk of health effects from eating vegetables from Flin Flon gardens.

Addresses of the authors:

Geoff Jones, Habitat Management and Ecosystem Monitoring Section, Wildlife and Ecosystem Protection Branch, Manitoba Conservation. Suite 160, 123 Main St. Winnipeg, MB. R3C 1A5. gjones@gov.mb.ca.

Vicki Henderson, Habitat Management and Ecosystem Monitoring Section, Wildlife and Ecosystem Protection Branch, Manitoba Conservation. Suite 160, 123 Main St. Winnipeg, MB. R3C 1A5. vhenderson@gov.mb.ca.

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RÉSUMÉ

Cette étude a été menée en 2002 pour analyser les concentrations de métaux et d'autres éléments dans les sols de jardins et les cultures légumières cultivées dans la ville de Flin Flon, au Manitoba, et pour évaluer les risques sanitaires associés à la consommation des légumes. Les mêmes cultivars de laitue, de haricots, de carottes, de pommes de terre et de tomates ont été plantés dans neuf jardins de Flin Flon, dans un jardin de Cranberry Portage et dans un jardin du Pas. Des échantillons répétés de sols et de légumes ont été recueillis de chaque jardin pendant les mois d'août et de septembre et ont été analysés pour connaître les concentrations totales de métaux et d'autres éléments définis.

Dans la plupart des jardins de Flin Flon par rapport au jardin du Pas, il y avait une forte corrélation entre les concentrations d'arsenic, de cadmium, de cuivre, de plomb, de mercure, de sélénium et de zinc, et ces concentrations étaient très élevées. Dans certains cas, les concentrations de ces éléments dans les jardins de Flin Flon dépassaient les niveaux établis dans les lignes directrices pour la qualité des sols, alors que les concentrations dans les sols des jardins de Cranberry Portage et du Pas ne les dépassaient pas. L'arsenic, le cadmium, le cuivre, le plomb, le mercure et le zinc sont des éléments connus des émissions atmosphériques passées et présentes de la fonderie de Hudson Bay Mining and Smelting (HBM&S) de Flin Flon.

Les concentrations d'arsenic, de cadmium, de cuivre, de plomb, de mercure, de sélénium et de zinc dans les légumes varient selon les sites et les variétés légumes. Dans la majorité des cas, les légumes cultivés à Flin Flon comptaient de plus fortes concentrations de ces métaux que les légumes cultivés au Pas. La laitue avait tendance à accumuler les plus fortes concentrations de ces métaux; venaient ensuite les carottes et les pommes de terre, les haricots et les tomates. Les concentrations de certains éléments dans les échantillons de légumes étaient souvent en forte corrélation avec les concentrations dans les sols. Par exemple, la corrélation entre les concentrations de mercure et de cadmium dans les échantillons lavés de laitue, de pomme de terre et de carotte et les concentrations dans le sol ($r > 0,7$) était élevée, suggérant que ces légumes avaient absorbé les métaux présents dans le sol. Les comparaisons entre les échantillons non lavés et les échantillons lavés de laitue indiquaient que le dépôt atmosphérique d'arsenic, de cuivre, de zinc et de plomb, et, peut-être à un degré moindre, de mercure, s'est produit pendant la saison de croissance de 2002. La source exacte de ces métaux n'est pas connue, mais il s'agit

probablement d'une combinaison de dépôts provenant des émissions de la fonderie, de la poussière du bassin d'accumulation de résidus, et de la poussière et des particules de la terre environnante.

Des lignes directrices provenant d'un certain nombre de sources et relatives aux doses journalières admissibles (DJA) ont été utilisées pour évaluer les risques sanitaires associés à l'absorption d'éléments par la consommation de légumes cultivés dans les jardins faisant l'objet de l'étude. Dans la plupart des cas, les montants consommés requis pour dépasser les niveaux des DJA étaient bien au-dessus de la dose journalière prévue pour chaque légume. Les niveaux des DJA sont fondés sur la consommation à long terme, alors que les légumes des jardins privés, en particulier la laitue, ne sont principalement consommés que pendant les deux à trois mois de la saison de croissance. De plus, les légumes provenant de jardins privés ne représentent généralement qu'une petite partie de l'alimentation quotidienne, et la consommation par les personnes les plus vulnérables (les tout-petits et les enfants) est généralement faible. Compte tenu de ces faits, il a été conclu que manger des légumes provenant des jardins de Flin Flon représente un risque très faible d'effets sur la santé.

Adresse des auteurs:

M. Geoff Jones, Section de l'aménagement de l'habitat et de la surveillance des écosystèmes, Direction de la protection de la faune et des écosystèmes, Conservation Manitoba, 123, rue Main, bureau 160, Winnipeg (Manitoba) R3C 1A5, gjones@gov.mb.ca.

M[me] Vicki Henderson, Section de l'aménagement de l'habitat et de la surveillance des écosystèmes, Direction de la protection de la faune et des écosystèmes, Conservation Manitoba, 123, rue Main, bureau 160, Winnipeg (Manitoba) R3C 1A5, vhenderson@gov.mb.ca.

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INTRODUCTION

The city of Flin Flon is located in west-central Manitoba adjacent to the Manitoba-Saskatchewan border (approximately 55° N, 102° W). The region is underlain by Precambrian greenstone-granitic bedrock of volcanic origin and as such contains sulphide ore bodies with significant quantities of economic metals including copper (Cu), zinc (Zn), and gold (Au). Mining and smelting of these metals has taken place in the Flin Flon area since 1930. The smelter complex (operated by Hudson Bay Mining & Smelting or HBM&S) is located on the west side of the community. Atmospheric emissions from the smelter operation have been released from a 250 m tall chimney since 1974. A series of smaller emission stacks (approximately 12 m high) was used prior to 1974. Metals and other elements in the stack emissions have included varying amounts of arsenic (As), cadmium (Cd), Cu, lead (Pb), mercury (Hg), and Zn (MAC 2002)

The purpose of this study was to determine the concentration of selected elements in garden soils and vegetable crops grown in the city of Flin Flon. Similar studies were conducted by Pip in 1989 (Pip 1991) and by HBM&S in 1994 (HBM&S Environment unpublished report 1994). Results from these studies were variable. For example, mean concentrations of Pb in some vegetable crops in the Pip study were four to five times higher than levels in similar crops in the HBM&S study. In response to public concern about this and other discrepancies between the two studies, the Habitat Management and Ecosystem Monitoring Section of Manitoba Conservation opted to design and conduct a systematic garden sampling program within the community. It was believed that a more systematic approach would produce more credible results than the earlier studies.

METHODS AND SITE SELECTION

A total of 11 gardens were selected for the study (Figure 1). Nine gardens were located in Flin Flon. Two other gardens, one located in the community of Cranberry Portage and the other located in the town of The Pas, were also included to represent a minimally impacted site and a non-impacted control site, respectively. An effort was made to choose gardens with soils of similar consistency, particle size, soil depth, and origin. The gardens were located at varying distances east, northeast, and southeast of the HBM&S smelter complex in order to provide a representative sample of gardens throughout the

community. The distance and general direction of each site from the HBM&S smelter complex are provided in Table 1.

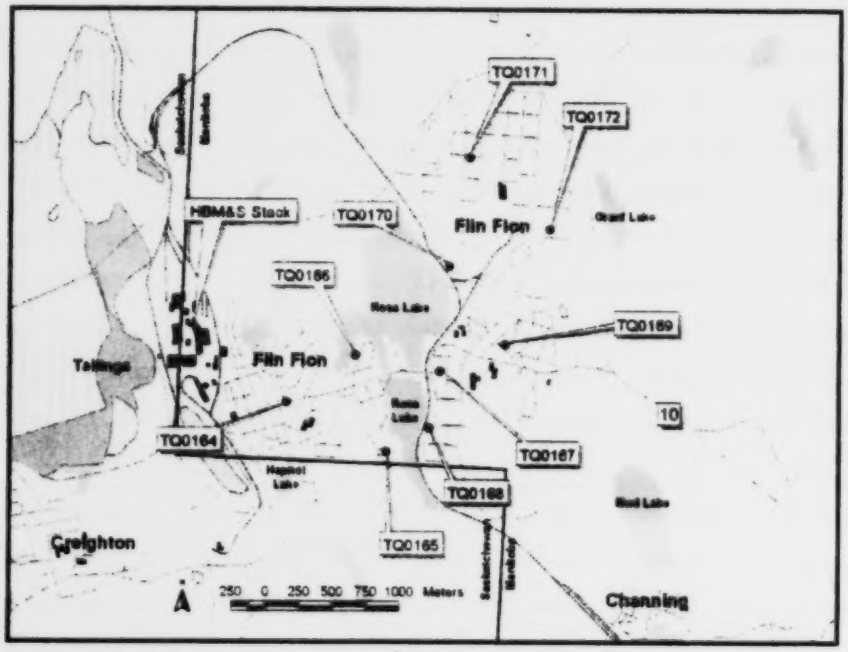

Figure 1. Map showing location of study sites (gardens).

A study plot measuring approximately 2.0 m x 2.5 m was established in each garden (Figure2). Plots were located away from any trees, shrubs, sheds, fences, decks, or other structures in order to minimize possible influences from shading and contamination from chemicals in wood preservatives, paints, and stains. Plots were tilled and weeds were removed in preparation for planting.

Table 1. Study sites with distance and direction away from the smelter complex

Garden Site	Location	Distance from Smelter (km)	Direction
TQ0164	Flin Flon	0.90	SE
TQ0165	Flin Flon	1.71	SE
TQ0166	Flin Flon	1.21	E
TQ0167	Flin Flon	1.85	E
TQ0168	Flin Flon	1.91	SE
TQ0169	Flin Flon	2.30	E
TQ0170	Flin Flon	1.93	NE
TQ0171	Flin Flon	2.37	NE
TQ0172	Flin Flon	2.71	NE
TQ0173	Cranberry Portage	38.23	SE
TQ0174	The Pas	115.01	SE

Figure 2. Example of a typical garden plot used in the study.

Four seed potatoes, four tomato seedlings (approximately 15 cm tall), and at least one row (2 m long) of carrots, beans, and lettuce were planted in each plot on June 7, 2002. The taller crops were planted at the north end of the plots to minimize shading of other vegetables within the plot. The same variety or cultivar of each vegetable was planted in each plot. Vegetable cultivars were obtained from T&T Seeds, Winnipeg, MB, and included the following:

Potato - Dark Red Norland (Early Red) (#9055),
Tomato - Prairie Pride (Bush Type) (04.8621 N1809-107),
Beans - Dandy Green (#60)
Lettuce - Buttercrunch (#925)
Carrots - Nantes Coreless (#440)

These specific cultivars were selected because they mature relatively rapidly and are generally tolerant of northern climatic conditions. Plots were watered and weeded regularly (as required) throughout June and July in order to maintain adequate soil moisture and minimize weed competition.

Potatoes, lettuce, beans, and carrots were harvested on August 12 and 13, 2002. The tomatoes were harvested on September 2, as they required a longer growing season to produce mature fruit. Three replicate samples of each vegetable crop were collected from each garden plot. Replicate samples of beans, carrots, and lettuce were a composite sample from several plants. Composite samples were collected in order to ensure an adequate amount of material was available for the laboratory analysis.

With a few exceptions, most replicate samples of tomatoes and potatoes were collected from individual plants. Only the edible portion of each vegetable was sampled.

Figure 3. Harvesting samples of lettuce from one of the study sites in Flin Flon.

Samples were put in labeled paper bags and immediately placed in coolers to prevent water loss. The wet mass (fresh weight) of each sample was determined within 4 hours of collection. Each of the lettuce, tomato, and bean replicate samples was divided and one half was washed with Flin Flon tap water while the other half was left unwashed. This was done to determine how much of the total concentration was attributable to elements on the surface versus elements in the vegetable tissue. Loose soil particles on carrot and potato samples were removed by hand prior to determining fresh weight. Although this often did not remove all of the soil particles, the amount remaining was considered insignificant to the total wet mass of the sample. After weighing, the carrot and potato samples were then washed thoroughly to remove any remaining soil particles. Vegetable production in gardens was variable and appeared unrelated to proximity to the smelter stack or level of soil contamination. In some gardens the amount of material available for analysis was too small to provide replicate washed and unwashed samples. In such cases only washed samples were submitted for analysis. Moisture content of all samples was determined by the weight loss on drying method. The samples were analyzed by Cantest Laboratories (Burnaby, BC) to determine the total concentration of metals and other elements. Results were reported as µg/g dry weight. A complete list of the variables analyzed in the vegetables is presented in Table 2, while the laboratory analysis methods are summarized in Appendix 1.

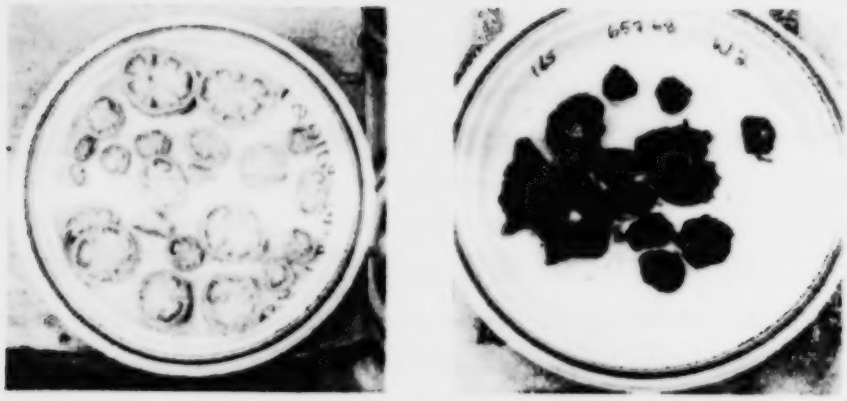

Figure 4. Vegetable samples (tomatoes in these pictures) were weighed before and after drying to determine moisture content.

Three replicate soil samples were collected from each plot in conjunction with the vegetable sampling in August (Figure 5). The soil samples were extracted with a 5 cm diameter soil corer to 10 cm depth, placed in labeled plastic bags, and stored in coolers prior to analysis. Soil samples were analyzed for moisture content, bulk density, pH, conductivity, fertility, and total concentration of selected metals and other elements (see Table 2). Results were reported as µg/g dry weight. A summary of the soil analysis methods used is available in Appendix 1.

Figure 5. Collecting a soil sample from one of the study sites in Flin Flon.

The location of each garden was geo-referenced with a *Garmin 12XL* GPS meter and a 1:50,000 scale map was produced using *Arview 3.2* (see Figure 1). The analytical data were summarized and presented in tabular and graphical form. Analysis of variance (ANOVA) and Tukey-Kramer multiple comparison tests (SAS 1997) were used to identify significant differences ($\alpha = 0.05$) in mean concentrations of elements in vegetables and in soil between sites. The Shapiro-Wilk W-test (SAS 1997) was used to test for normality in the data. Data that were not normally distributed were $\log_{10}$ transformed and tested again for normality prior to ANOVA and multiple comparison testing. Dunnet's test ($\alpha = 0.05$) (SAS 1997) was used to determine if mean concentrations of elements in soil and vegetables from each of the garden sites in Flin Flon and Cranberry Portage differed significantly from concentrations at the control site in The Pas. Student's *t*-tests ($\alpha = 0.05$) (SAS 1997) were used to compare the mean concentrations of metals in unwashed and washed samples of beans, lettuce, and tomatoes. This was done to determine if washing the vegetables had any significant affect on the amount of metals present and to show whether the metals were on the surface of the vegetables or in the tissue. Also, the relationship between soil metal content and the metal content of vegetable crops was explored using Pearson product-moment correlation analysis (SAS 1997). The health risk associated with consuming the produce was assessed by comparing to tolerable intake values gleaned from a number of sources in the literature. Finally, results from this 2002 study were compared to concentrations reported in the Pip (1991) and HBM&S (1994) studies.

RESULTS AND DISCUSSIONS

Metals and Other Elements in Soil

General Results

Thirty-three soil samples were collected and analyzed for general chemistry, nutrient status, and metal and other element content. Most analytes were present at concentrations higher than the laboratory detection limit. The soil analysis results for each sample are found in Appendix 2.

ANOVA and multiple comparison tests indicated that mean concentrations of elements in the soil often varied significantly between sites in Flin Flon as well as between the Flin Flon sites and the sites at Cranberry Portage and The Pas. Dunnet's tests (used to compare control concentrations with those of other sites) indicated that mean concentrations of several elements, including As, Cd, Cu, Pb, Hg, Zn, selenium (Se), chromium (Cr), vanadium (V), and titanium (Ti), were significantly higher in most of the

Flin Flon garden soils than in soil from the control garden in The Pas. The mean concentrations and results from the multiple comparison testing of these elements are presented in Table 3.

Table 2. List of analytes tested in soils and vegetation samples.

Soil Analysis			
Analyte	Symbol	Detection Limit	Unit
Moisture Content		0.1	%
Bulk Density		0.01	g/cm³
pH		0.1	pH units
Conductivity		0.1	mmhos/cm
Available Nutrients:			
Nitrate & Nitrite (as N)	NO_3-NO_2 as N	0.4	µg/g
Sulphate	SO_4	1	µg/g
Phosphorus	P	1	µg/g
Potassium	K	10	µg/g
Exchangeable Cations:			
Aluminum	Al	20	µg/g
Calcium	Ca	1	me/100g
Iron	Fe	1	µg/g
Magnesium	Mg	1	me/100g
Manganese	Mn	2	µg/g
Potassium	K	0.01	me/100g
Sodium	Na	0.01	me/100g
Total Metals and Other Elements:			
Aluminum	Al	10	µg/g
Antimony	Sb	10	µg/g
Arsenic	As	0.1	µg/g
Barium	Ba	1	µg/g
Beryllium	Be	1	µg/g
Boron	B	1	µg/g
Cadmium	Cd	0.2	µg/g
Calcium	Ca	1	µg/g
Chromium	Cr	2	µg/g
Cobalt	Co	1	µg/g
Copper	Cu	1	µg/g
Iron	Fe	2	µg/g
Lead	Pb	5	µg/g
Magnesium	Mg	0.1	µg/g
Manganese	Mn	1	µg/g
Mercury	Hg	0.01	µg/g
Molybdenum	Mo	4	µg/g
Nickel	Ni	2	µg/g
Phosphorus (as phosphate)	PO_4	20	µg/g
Potassium	K	10	µg/g
Selenium	Se	0.2	µg/g
Silver	Ag	0.1	µg/g
Sodium	Na	5	µg/g
Strontium	Sr	1	µg/g
Sulphur	S	0.01	%
Thallium	Tl	0.1	µg/g
Tin	Sn	5	µg/g
Titanium	Ti	1	µg/g
Vanadium	V	1	µg/g
Zinc	Zn	1	µg/g
Zirconium	Zr	1	µg/g

Vegetation Analysis			
Analyte	Symbol	Detection Limit	Unit
Moisture Content		0.1	%
Total Metals and Other Elements:			
Aluminum	Al	0.5	µg/g
Antimony	Sb	0.1	µg/g
Arsenic	As	0.1	µg/g
Barium	Ba	0.1	µg/g
Beryllium	Be	0.02	µg/g
Boron	B	2	µg/g
Cadmium	Cd	0.02	µg/g
Calcium	Ca	1	µg/g
Chromium	Cr	0.1	µg/g
Cobalt	Co	0.1	µg/g
Copper	Cu	0.1	µg/g
Iron	Fe	5	µg/g
Lead	Pb	0.1	µg/g
Magnesium	Mg	0.5	µg/g
Manganese	Mn	0.1	µg/g
Mercury	Hg	0.01	µg/g
Molybdenum	Mo	0.1	µg/g
Nickel	Ni	0.1	µg/g
Phosphorus (as phosphate)	PO_4	0.5	µg/g
Potassium	K	5	µg/g
Selenium	Se	0.2	µg/g
Silicon (as silicon dioxide)	SiO_2	10	µg/g
Silver	Ag	0.01	µg/g
Sodium	Na	1	µg/g
Strontium	Sr	0.05	µg/g
Sulphur	S	25	µg/g
Tellurium	Te	0.1	µg/g
Thallium	Tl	0.02	µg/g
Tin	Sn	0.1	µg/g
Titanium	Ti	0.3	µg/g
Uranium	U	0.04	µg/g
Vanadium	V	0.5	µg/g
Zinc	Zn	0.5	µg/g
Zirconium	Zr	3	µg/g

Table 3. Mean concentrations (n = 3) of selected elements in the 11 study sites. Means with the same letter are not significantly different ($\alpha = 0.05$). Distance (km) is from the HBM&S smelter.

Variable	TQ0164 Flin Flon	TQ0166 Flin Flon	TQ0165 Flin Flon	TQ0167 Flin Flon	TQ0168 Flin Flon	TQ0170 Flin Flon	TQ0169 Flin Flon	TQ0171 Flin Flon	TQ0172 Flin Flon	TQ0173 Cranberry Portage	TQ0174 The Pas
As	44.6 a	9.1 bc	13.0 b	13.3 b	12.1 b	8.6 bc	8.9 bc	6.1 cd	3.0 e	2.2 e	5.0 d
Cd	10.5 a	2.8 c	5.9 b	5.2 b	2.7 c	2.3 c	2.7 c	1.9 c	0.8 d	0.4 e	0.3 e
Cr	42 a	26 de	33 bcde	42 ab	37 bc	43 ab	30 cde	50 a	35 bcd	24 e	12 f
Cu	584 a	198 bc	314 abc	255 bcd	410 ab	172 cd	172 cd	125 d	63 e	23 f	14 f
Pb	370 a	69 cde	213 ab	131 bc	90 bcd	47 def	55 cde	29 ef	11 fgh	26 fg	7 h
Hg	25.03 a	6.37 b	6.09 b	3.03 bc	2.76 bc	1.43 c	1.39 c	1.97 c	0.57 d	0.11 e	0.03 f
Se	5.7 a	2.0 bc	2.3 b	1.6 bcd	1.3 de	0.9 e	1.3 cd	0.9 e	0.4 f	0.3 fg	0.5 f
Ag	1.0 ab	0.3 d	1.2 a	0.6 bcd	1.0 abc	0.3 d	0.4 d	0.5 cd	0.1 e	< 0.1 e	< 0.1 e
Zn	2990 a	669 c	1423 b	1593 b	1167 bc	957 bc	735 c	737 c	288 d	131 e	58 f
Ti	413 def	371 ef	355 ef	569 bcd	592 bc	673 ab	452 cde	805 a	664 ab	247 f	22 g
V	34 bcde	24 ef	26 def	37 abc	35 bcd	42 ab	31 cde	47 a	35 bcd	25 ef	17 f
Distance	0.90	1.21	1.71	1.85	1.91	1.93	2.30	2.37	2.71	38.23	115.01

Note that in Table 3 (and subsequent tables and figures) the study gardens are arranged according to their distance from the smelter complex. This is for presentation purposes only. Numerous studies, including those by Wotton (1979), McEachern and Phillips (1983), Hogan and Wotton (1984), Zoltai (1988), Henderson and McMartin (1995), Henderson *et al.* (1998), and McMartin *et al.* (1999), have reported strong inverse relationships between soil concentrations of As, Cd, Cu, Pb, Hg, and Zn and distance from the HBM&S smelter. However, the present study was not designed to investigate the specific relationship between soil metal concentrations and distance from the smelter. Relationships between concentrations and distance (*e.g.* using regression analyses) may not be found because the garden sites were located close to (within 3 km) the smelter complex, had been exposed to smelter emissions over different numbers of years, were not positioned along the same exposure gradient, and may have been subject to different gardening practices.

Data analysis showed that As, Cd, Cu, Pb, Hg, Se, and Zn concentrations were all highly correlated with each other (Table 4). This means, for example, that high concentrations of As in the soil were accompanied by high concentrations of Cd, Cu, Pb, Hg, Se, and Zn. Arsenic, Cd, Cu, Pb, Hg, and Zn are known constituents of the HBM&S smelter emissions (MAC 2002). It is likely that Se is also a constituent of the HBM&S smelter emissions since it is often present in sulphide ores in association with Cu and Pb (ATSDR 2001). The fact that these metals are constituents of atmospheric emissions from the smelter, are correlated in the soil, and, for the most part, were more concentrated in Flin Flon gardens than in the controls implies that the smelter is the likely source of these elements in the Flin Flon soils. It must be emphasized that these metals have accumulated over several decades and the present concentrations represent the cumulative impact of smelter stack emissions and airborne particulates (dust) from the nearby tailings ponds. They do not necessarily mirror what is being deposited now or even what has been deposited in the recent past. Multiple comparison tests (Table 3) also indicated that

mean soil concentrations of As, Cd, Cu, Hg, Se, and silver (Ag) from the Cranberry Portage site did not differ significantly from the site in The Pas.

Silver, which was found in only trace amounts (usually less than 1 μg/g) at the garden sites, was also positively correlated with concentrations of As, Cd, Cu, Pb, Hg, Se, and Zn. However, correlations with Ag were generally not as strong as the inter-correlations between As, Cd, Cu, Pb, Hg, Se, and Zn. Chromium, V, and Ti were well correlated with each other and with elements such as aluminum (Al), and iron (Fe), but were poorly correlated with the As, Cd, Cu, Pb, Hg, Se, Ag, and Zn. This suggests that the levels of Cr, V, and Ti, although significantly higher in the Flin Flon gardens than in the control garden in The Pas, are likely natural in origin or at least originate from sources other than the smelter emissions.

Table 4. Correlation of soil concentrations of selected metals in the 11 study sites.

	As	*Cd*	*Cu*	*Pb*	*Hg*	*Se*	*Ag*	*Zn*	*Cr*	*Ti*	*V*	*Al*	*Fe*
As	1.00												
Cd	**0.93**	1.00											
Cu	**0.80**	**0.83**	1.00										
Pb	**0.92**	**0.96**	**0.83**	1.00									
Hg	**0.96**	**0.90**	**0.75**	**0.89**	1.00								
Se	**0.97**	**0.95**	**0.82**	**0.94**	**0.98**	1.00							
Ag	0.56	**0.69**	**0.87**	**0.70**	0.49	0.60	1.00						
Zn	**0.93**	**0.98**	**0.87**	**0.92**	**0.87**	**0.91**	**0.71**	1.00					
Cr	0.32	0.41	0.39	0.29	0.26	0.27	0.35	0.53	1.00				
Ti	-0.03	0.05	0.14	-0.08	-0.07	-0.07	0.11	0.18	**0.89**	1.00			
V	0.10	0.14	0.17	0.01	0.04	0.02	0.13	0.28	**0.95**	**0.94**	1.00		
Al	0.16	0.18	0.24	0.04	0.06	0.06	0.20	0.34	**0.91**	**0.89**	**0.96**	1.00	
Fe	0.23	0.23	0.33	0.14	0.09	0.10	0.38	0.39	**0.81**	**0.69**	**0.82**	**0.92**	1.00

Arsenic (As)

Arsenic is a naturally occurring metalloid (metal-like) element usually found in only trace amounts in the soil (CCME 1999, ATSDR 2000). The main natural source of As in soil is weathering of igneous and sedimentary rocks that contain the element. However, because As is often a minor constituent in ores that contain Pb, Cu, Zn, Ag, and Au, the mining and smelting of these metals can result in the release of As into the environment (CCME 1999). Application of human biosolids (sewage) and pesticides to land and the use of As (along with Cu and Cr) in treated wood products are other anthropogenic sources of As in the soil.

Arsenic is toxic to most plants and animals. Toxicity depends on the form of As present (inorganic forms are generally more toxic) and varies between plant species and between animal species. Research has shown that inhalation of As increases the risk of lung cancer in humans, while ingestion has been linked to an increased risk of developing skin cancer and tumor formation in the bladder, kidneys, liver, and lungs (CCME 1999, ATSDR 2000).

Mean As concentrations in the garden soils ranged from a low of 2.2 µg/g at the Cranberry Portage site (TQ0173) to a high of 44.6 µg/g at site TQ0164 in Flin Flon (Table 3, Figure 6). The mean concentration of As at the control site in The Pas was 5.0 µg/g. This concentration was significantly higher than concentrations at the Cranberry Portage site and at Flin Flon site TQ0172, and not significantly different than levels at Flin Flon site TQ0171. However, it was still significantly lower than mean concentrations at the majority of sites in Flin Flon (Figure 6).

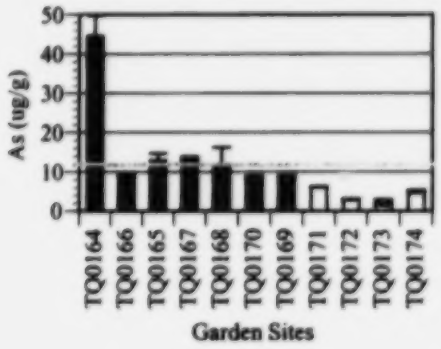

Figure 6. Mean As concentration (± SD, n = 3) in soil at each study site. The horizontal line is the soil quality guideline for the protection of human health for inorganic As. Shading shows if the mean concentration was significantly higher (black), lower (gray), or not significantly different (white) than the mean concentration at TQ0174.

Canadian soil quality guidelines have been established for a number of trace metals found in soil (CCME 1999). The guidelines are scientifically defensible numerical limits that were developed to protect both environmental and human health within four main classes of land use: (1) agricultural, (2) residential/parkland, (3) commercial, and (4) industrial (CCME 1999). Guidelines for human health and for environmental health can differ depending on the chemical or element in question and the type of land use involved. The final overall CCME guideline for a substance in soil is always the lower of the two for each of the four land use categories (CCME 1999). However, because this investigation was centered on private gardens in an urban setting, only the guidelines derived specifically for the protection of human health will be used to assess the soil results.

Soil quality guidelines for As are derived for inorganic As and not total As because the element is far more toxic in its inorganic forms. The soil quality guideline for As for the protection of human health is 12 µg/g for all land use classes. This guideline is based on the health risk associated with soil ingestion. This guideline was exceeded in soil from Flin Flon site TQ0164 and slightly exceeded in soil from Flin Flon sites TQ0165, 167, and 168 (Figure 6). However, as noted earlier, the soil quality guidelines for As and other metals are for general purposes only and site-specific conditions have to be considered in the application of these values.

Cadmium (Cd)

Cadmium is a metallic element found in small amounts in the earth's crust where it is usually associated with Zn, Pb, and Cu ores (CCME 1999). Cadmium has a number of industrial applications such as metal plating and is an important ingredient in nickel-cadmium storage batteries, solders, and electrical equipment. Cadmium enters the soil environment through natural weathering of igneous rocks and sedimentary shale, particulate fallout from mining industry emissions and fossil fuel combustion, land application of sewage sludge, and from fertilizer applications to agricultural lands (it is in some phosphate fertilizers) (CCME 1987, CCME 1999).

Uptake of Cd by plants varies depending on the plant species involved and the Cd content and chemistry of the soil. In general, plants readily absorb Cd from the soil and assimilate or store it in their tissues. Thus, vegetable and cereal crops tend to be the main source of Cd intake by humans (Codex Alimentarius Commission 1998, CCME 1999), although consumption of herbivore organ meats can also contribute to the dietary intake (CCME 1987, Codex Alimentarius Commission 1998). Chronic long-term exposure to Cd can cause gastrointestinal problems, bone deterioration, and kidney disease (CCME 1987, Codex Alimentarius Commission 1998). Cadmium is recognized as a carcinogen in humans. This conclusion is based primarily on studies linking inhalation of Cd compounds with increased risk of developing lung cancer (U.S. Department of Health and Human Services 2004). Recent studies assessing tumor development in test animals following injection and ingestion of Cd compounds are presently inconclusive, although research continues (U.S. Department of Health and Human Services 2004).

Cadmium was detected in all but one (a single replicate sample from the Cranberry Portage garden) of the soil samples. Mean concentrations of Cd ranged from 0.3 µg/g at the garden in The Pas to 10.5 µg/g at garden site TQ0164 in Flin Flon (Table 3, Figure 7). Cadmium concentrations were significantly higher in soil from the Flin Flon gardens than in soil from the gardens in Cranberry Portage and The Pas. Mean concentrations in the gardens in these latter two communities did not differ significantly from each other. This indicates that Cd emitted from the smelter has impacted the gardens in Flin Flon, but has not

significantly impacted the Cranberry Portage garden. Concentrations of Cd also differed between gardens within Flin Flon. This was likely related to distance and direction from the smelter as well as variations in gardening practices, the origin of the soil, and the age of the garden (period of exposure).

The guideline for Cd in soil used for agricultural purposes is 1.4 µg/g. This guideline is designed to protect human health from the potential risk of exposure to Cd via the soil-plant pathway. The CCME (1999) document recommends that this guideline be considered where produce gardens are being planted in residential/parkland areas. This guideline was exceeded in all but one of the Flin Flon sites (Figure 7). The human health protection guideline for residential/parkland use is 14µg/g and was not exceeded at any of the sites sampled.

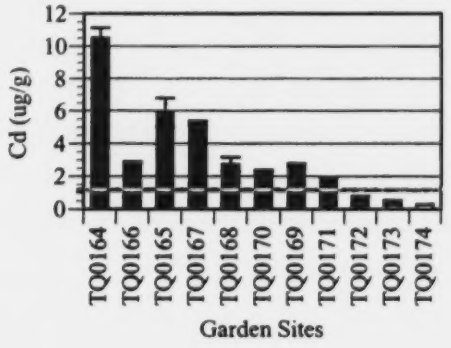

Figure 7. Mean Cd concentration (± SD, n = 3) in soil at each study site. The horizontal line is the soil quality guideline for the protection of human health for Cd in agricultural soil, Shading shows if the mean concentration was significantly higher (black), lower (gray), or not significantly different (white) than the mean concentration at TQ0174.

Copper (Cu)

Copper is a metallic element that can occur in nature in pure form, but is more often associated with other metals in mineral complexes (CCME 1999). Copper is used extensively in the production of electrical wire, plumbing pipes, and numerous metal alloys. It is also an important constituent in pesticides used to protect and preserve wood and to control algae and other plant growth in water supplies used for drinking. Weathering of rocks and minerals, the use of Cu compounds in some pesticides and fertilizers, the land application of biosolids, and emissions from mining and smelting operations are the most common pathways for Cu into soil (WHO 1998).

Copper is an essential micro-nutrient required for plant and animal growth (CCME 1987). It is involved in protein synthesis and enzymatic activity in plants and is thought to play a role in

photosynthesis (Tucker 1999). However, as with most micro-nutrients, there is a narrow optimal range in concentration in which plants will grow. Not enough Cu in the soil will lead to Cu deficiency, while too much Cu can affect a plant's ability to uptake Fe (another essential micro-nutrient) (Brady 1974), causing symptoms of iron chlorosis in the leaves and poor root development (CCME 1999). Hartmann *et al.* (1981) suggested that the approximate optimal range for Cu in cultivated plants is 4 to 15 µg/g (dry weight) and that toxic effects may be observed at concentrations above 20 µg/g (dry weight). In humans Cu is a component of enzymes involved in skin and bone development and in the proper functioning of the nervous and circulatory systems (Wood 2001). Many foods contain Cu and humans normally ingest about 1000 µg (1 mg) of Cu each day (ATSDR 2002). As such, Cu is considered non-toxic to humans except at very high concentrations (WHO 1998, CCME 1999).

Mean concentrations of Cu in garden soils ranged from 14 µg/g at the control site in The Pas to 584 µg/g at site TQ0164 in Flin Flon (Table 3, Figure 8). Mean concentrations of Cu in gardens in Flin Flon, although quite variable, were all significantly higher than concentrations at the control site in The Pas and the Cranberry Portage site. Thus, as with Cd, it appears that Cu from smelter emissions in Flin Flon has not been deposited to any significant degree at the garden site in Cranberry Portage.

The soil quality guideline for Cu for the protection of human health is 1100 µg/g in agricultural and residential/parkland soils, and 4000 µg/g and 16000 µg/g in soils intended for commercial and industrial use (respectively) (CCME 1999). The highest mean concentration of Cu in Flin Flon garden soil was 584 µg/g, which was still well below the level that would pose a potential health risk to humans.

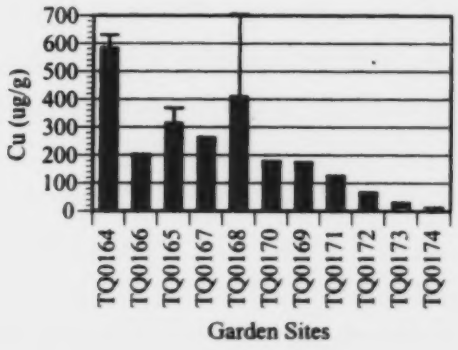

Figure 8. Mean Cu concentration (± SD, n = 3) in soil at each study site. The shading indicates whether the mean concentration was significantly higher (black), lower (gray) or not significantly different (white) than the mean concentration at TQ0174.

Lead (Pb)

Lead is one of the most common heavy metals found in the earth's crust (CCME 1987), but rarely occurs in its elemental form in nature (CCME 1999). It is found in over 200 different minerals, the most common and economically important being galena (PbS). Lead is used in the production of storage batteries and is an important ingredient in the manufacture of numerous chemical compounds (CCME 1999). Weathering of minerals containing Pb is the main natural pathway for Pb to enter soil. Lead is often associated with ores containing Zn and atmospheric deposition from the mining and smelting industry is a significant anthropogenic source of Pb in soil (CCME 1999). Other anthropogenic sources of Pb include exhaust from vehicles fueled with leaded gasoline, lead-based paints, and (arsenate) pesticides (Mercier *et al.* 2001). The background level of Pb in uncontaminated Canadian Shield soils has been estimated at approximately 21 µg/g (McKeague and Wolynetz 1980, cited in CCME 1999). This, however, may vary considerably depending on the underlying geology.

Because its solubility in water is low, only a small portion of the total Pb in soil is available for plant uptake. However, the Pb that is absorbed is readily bioaccumulated (stored in tissues and organs) by plants and by organisms farther up the food chain. Thus, even low concentrations of Pb can have toxic effects on organisms that experience prolonged exposure (WHO 2000). The metal has an affinity to bond with protein molecules in the body which can lead to a reduction in haemoglobin synthesis, hypertension and cardiovascular disease, neurological problems such as encephalopathy, and the disruption of renal system functions (kidney damage) (WHO 2000).

Mean concentrations of Pb in garden soils ranged from 7 µg/g at the control site in The Pas to 370 µg/g at site TQ0164 in Flin Flon (Table 3, Figure 9). The amount of Pb in soils in Flin Flon varied significantly between garden sites. Mean concentrations of Pb tended to be significantly higher at sites closest to the smelter and decreased with increasing distance away from the smelter. With the exception of site TQ0172 in Flin Flon, all of the gardens (including TQ0173 at Cranberry Portage) had mean concentrations of Pb significantly higher than the concentration at the control site in The Pas.

The soil quality guidelines for Pb for the protection of human health are 140 µg/g for agriculture and residential/parkland land uses, 260 µg/g for commercial land use, and 600 µg/g for industrial land use. These guidelines are based on the possible toxic effects of long term exposure to Pb through soil ingestion (CCME 1999). The human health protection guideline of 140 µg/g for soil used for agricultural and residential/parkland purposes was only exceeded at sites TQ0164 and TQ0165. Soil at site TQ0164 also exceeded the guideline for commercial land use.

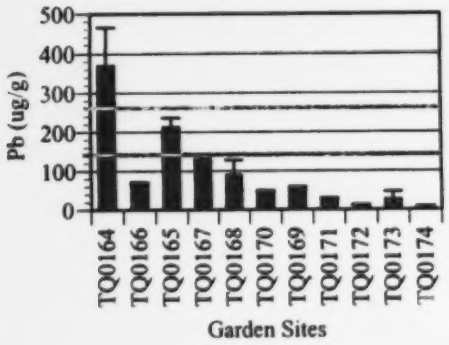

Figure 9. Mean Pb concentration (± SD, n = 3) in soil at each study site. The lower horizontal line is the soil quality guideline for Pb for the protection of human health in agricultural and residential/parkland soils, while the upper line is the guideline for Pb in soils intended for commercial land use. Shading indicates whether the mean concentration was significantly higher (black), lower (gray), or not significantly different (white) than the mean concentration at TQ0174.

Mercury (Hg)

Mercury is the only naturally occurring heavy metal that is liquid in its elemental form (between –38.9°C and 357°C) (Brady and Holum 1981). Mercury has a variety of industrial uses including the production of paint pigments and wood preservatives, and the manufacturing of pulp and paper products (CCME 1987). Mercury was once used extensively in the production of mercury-based pesticides, but because of environmental and health concerns, the production and use of such pesticides have been severely restricted (CCME 1987).

The chemistry of Hg in the environment is complex. It occurs naturally as metallic or elemental Hg, in inorganic salts such as mercuric sulphide (cinnabar), and in numerous organic compounds (organomercurials), the most common of which is methyl mercury (ATSDR 1999). Mercury and its compounds are present (usually in minute quantities) in the atmosphere, soil, groundwater, and surface water. The major pathways for Hg into soil include weathering of rocks and minerals that contain Hg, precipitation, solid and liquid domestic waste disposal, particulate fallout from burning fossil fuels, and emissions from certain mining and smelting operations (CCME 1987, ATSDR 1999).

Mercury bioaccumulates and can reach concentrations in certain organisms that are much higher than the surrounding environment (CCME 1987). The primary pathway for Hg to enter the human body is through ingestion of food containing methyl mercury (ATSDR 1999). There is evidence that prolonged exposure to Hg through inhalation and ingestion of methyl mercury can result in neurological damage (CCME 1987, WHO 1990).

Mean total Hg concentrations in soil samples collected from the study gardens ranged from 0.3 µg/g at the control site in The Pas to a high of 25.03 µg/g at site TQ0164 in Flin Flon (Table 3, Figure 10). All the sites, including the garden in Cranberry Portage, had significantly higher concentrations of Hg than the site in The Pas. Levels of Hg in the Flin Flon gardens were variable, with the highest concentrations occurring in gardens TQ0164, TQ0165, and TQ0166.

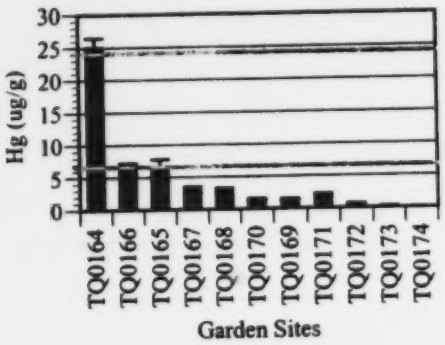

Figure 10. Mean Hg concentration (± SD, n = 3) in soil at each study site. The lower horizontal line is the soil quality guideline for Hg for the protection of human health for agricultural and residential/parkland land use, while the upper line is the guideline for commercial land use. Shading shows if the mean concentration was significantly higher (black), lower (gray), or not significantly different (white) than the mean concentration at TQ0174.

The guideline for Hg for the protection of human health in agricultural and residential/parkland soils is 6.6 µg/g, while the guidelines for commercial and industrial land uses are 24 µg/g and 99 µg/g, respectively. The guidelines for agricultural, residential/parkland, and commercial land uses are designed to protect human health based on the risk of exposure through soil ingestion. The guideline for industrial land use is based on risks to human health from off-site migration of Hg. The mean Hg concentration in soil at site TQ0164 exceeded the soil quality guidelines for agricultural, residential/parkland, and commercial land use (Figure 10). Two other Flin Flon gardens (TQ0165 and TQ0166) had mean concentrations of Hg approaching the agricultural and residential/parkland land use guideline. It must be stressed, however, that the Hg concentrations recorded in this study are total concentrations, while the guidelines are specifically derived for inorganic Hg. The inorganic portion of the total Hg in soil can vary considerably depending on soil chemistry and physical properties. Characteristics such as clay and organic matter content, pH, and the concentration of other elements in the soil can influence the amount of inorganic Hg present (CCME 1999).

Selenium (Se)

Selenium is a metallic element that is widely distributed in the earth's crust at low concentrations (ATSDR 2001). Selenium is relatively reactive in nature and combines with other elements to form a large number of compounds including bromides, chlorides, fluorides, oxides, and sulphides (CCME 1999). Selenium is also found in minerals containing nickel (Ni), Cu, Pb, and Ag (ATSDR 2001) and is often obtained as a by-product of Cu and Pb smelting and refining operations. Selenium is used in the production of electrical components, metallurgical industries, glass and ceramic production, and the manufacture of certain pharmaceuticals (CCME 1987). In Canada, which is one of the world's leading producers, it is used mainly in glass making (CCME 1999). Weathering of rocks and minerals is the main natural pathway for Se into the soil environment, while fertilizer and pesticide applications, fallout from burning fossil fuels, and copper mining and smelting emissions are anthropogenic sources (CCME 1999).

Selenium is an essential element for some plants and most animals. Plant uptake of Se is strongly influenced by the form of Se in the soil and the pH, soil texture, organic matter content, and presence of other ions in the soil matrix (CCME 1999). Animals require only trace amounts of the element and prolonged ingestion of higher concentrations can become toxic (CCME 1999). For example, the optimal range for Se in animal feed is very narrow (Carlson *et al.* 1991), with concentrations in feed below 0.10 µg/g producing deficiency symptoms in livestock and prolonged exposure to concentrations above 2 to 5 µg/g resulting in potential toxicity (Gissel-Nielson *et al.* 1984). The recommended daily human intake of Se is 1 µg/kg/bw (bw = body weight) or 70 µg for a 70 kg adult (CCME 1999).

Mean concentrations of Se in the garden soils of this study ranged from 0.3 µg/g at the Cranberry Portage site to 5.7 µg/g at Flin Flon site TQ0164 (Table 3, Figure 11). Mean concentrations at the site in The Pas and at site TQ0172 in Flin Flon were slightly higher, but not significantly different than the concentration recorded at the site in Cranberry Portage. The rest of the gardens all had significantly higher mean concentrations of Se, which, excluding site TQ0164, ranged from 0.9 µg/g to 2.3µg/g.

The guideline for Se for the protection of human health in soil intended for agricultural and residential/parkland use is 28 µg/g, while the guidelines for commercial and industrial land uses are 100 µg/g and 400 µg/g, respectively. The agricultural , residential/parkland, and commercial land use guidelines are based on the risk to human health from soil ingestion, while the industrial land use guideline is based on potential risk from off-site migration of Se. All of the garden soils had mean Se concentrations well below the human health protection guideline levels.

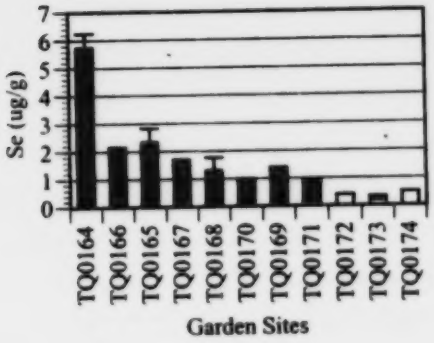

Figure 11. Mean Se concentration (± SD, n = 3) in soil at each study site. Shading shows if the mean concentration was significantly higher (black), lower (gray), or not significantly different (white) than the mean concentration at TQ0174.

Silver (Ag)

Silver is a rare, economically important metal that, although occurring sometimes in its elemental (pure) form in nature, is usually associated with other elements in mineral compounds (ATSDR 1990). Although uncommon, it is fairly widely distributed in the earth's crust (CCME 1987) and its unique characteristics (*e.g.* high luster when polished, sensitivity to light, and high thermal and electrical conductivity) make mining activities commercially viable. Silver is used predominantly in the production of photographic materials, coinage, sterling and silver plated wares, jewelry, mirrors, dental and medical supplies, solders, some fungicides, and electrical components and batteries (CCME 1987). Silver enters the soil environment naturally through weathering of rocks and volcanic activity and also via landfill, land application of biosolids, emissions from mining, iron and steel manufacturing, and crude oil production (CCME 1987, ATSDR 1990).

There are no Canadian soil quality guidelines for Ag. However, there are interim soil quality criteria for the metal in soil. Interim soil quality criteria are numerical limits for contaminants in soil that are intended to provide protection and maintenance of environmental and human health at contaminated sites (CCME 1991). The two types of soil quality criteria are assessment criteria and remediation criteria. Assessment criteria approximate the background or ambient concentrations of substances in soil. If the concentration of a substance in the soil does not exceed its assessment criterion, then the soil is considered uncontaminated and no environmental or human health risk exists. Remediation criteria are numerical values that can be used as a basis for further investigation of a potentially contaminated site or remediation of an identified contaminated site. As with the soil quality guidelines, the remediation criterion for a specific contaminant in soil may differ depending on whether the land use is agricultural, residential/parkland, or commercial/industrial. The degree to which the remediation criteria are exceeded

can be used to gauge the urgency of the problem and help to decide what type of action needs to be taken. As well, the remediation criteria can be used to identify land use restrictions. It is important to keep in mind that these criteria are only for interim guidance.

Silver was below detection (<0.1 µg/g) in the gardens in The Pas and Cranberry Portage and ranged from 0.1 µg/g (site TQ0172) to 1.2 µg/g (site TQ0165) in the gardens in Flin Flon (Table 3, Figure 12). The interim assessment criterion for Ag in soil is 2 µg/g, while the interim remediation criteria are 20 µg/g for agricultural and residential/parkland land use and 40 µg/g for commercial/industrial land use. Thus, although the mean concentrations of Ag were significantly higher in the Flin Flon gardens than in the gardens in Cranberry Portage and The Pas, they were well below levels that might be of concern from a human health perspective.

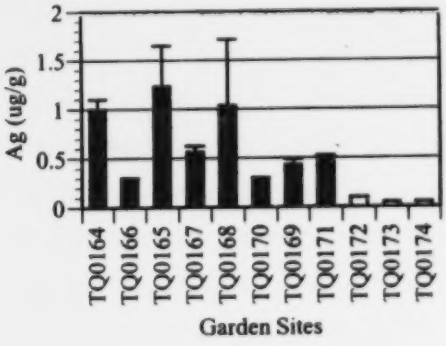

Figure 12. Mean Ag concentration (± SD, n = 3) in soil at each study site. The horizontal line at the top of the graph is the interim assessment criterion for Ag in soil. Shading shows if the mean concentration was significantly higher (black), lower (gray), or not significantly different (white) than the mean concentration at TQ0174.

Zinc (Zn)

Zinc is an economically important metallic element. It is used extensively in galvanizing and is a component in alloys such as bronze (with Cu and tin) and brass (with Cu), which are widely used in plumbing, heating, and cooling systems (CCME 1987). Zinc is quite reactive and bonds readily with organic and inorganic compounds in the soil (CCME 1999). Because it is so reactive it is found in numerous rock types and minerals (including silicates, sulphides, and oxides) (Brady 1974). Sulphide minerals containing Zn (e.g. ZnS) are generally associated with Fe, Cu, and Pb deposits, and Zn production is often a by-product of the extraction of these elements. Weathering of rocks and minerals containing Zn is the main natural pathway for Zn into the soil. Anthropogenic inputs of Zn to the soil include fallout from smelter and refinery emissions and corrosion of Zn alloys and galvanized surfaces (CCME 1999). Once in the soil, Zn tends to be fairly evenly distributed through the soil profile (CCME

1999), although atmospheric deposition can result in Zn accumulation in the upper soil layer if the soil is high in organic matter (Frank *et al.* 1976, Hogan and Wotton 1980). Zinc concentrations in Canadian soils vary geographically. A mean concentration of 54 µg/g has been calculated for soils of the Canadian Shield (McKeague and Wolonetz 1980).

Zinc is an essential micronutrient required for enzyme production and protein synthesis in both plants and animals (Starr and Taggart 1987). However, like most micronutrients, too much Zn in the soil can become toxic for plants. Brady (1974) states that the usual range of Zn concentrations in plant tissues is 15 to 200 µg/g. Hartmann *et al.* (1981) suggested that Zn in the tissues of cultivated plants might become toxic above a concentration of 200 µg/g (dry weight), while optimal concentrations should range between 15 and 50 µg/g. Signs of Zn toxicity in plants include leaf chlorosis and stunted growth (CCME 1999).

The mean concentration of Zn in the garden soils ranged from 55 µg/g at The Pas to 2990 µg/g at site TQ0164 in Flin Flon (Table 3, Figure 13). Mean Zn levels in the Flin Flon and Cranberry Portage gardens were significantly higher than the control site in The Pas. In turn, the mean levels of Zn at the Flin Flon sites were all significantly higher than the mean concentration at the site in Cranberry Portage. Guidelines for the protection of human health have not been calculated for Zn concentrations in soil. This is partly due to the fact that Zn is an important micro-nutrient in the human diet and is only considered toxic at very high concentrations. Soil quality guidelines to protect environmental health have been developed (i.e. 200 µg/g for agricultural and residential/parkland land use, and 360 µg/g for commercial and industrial land use) (CCME 1999). However, since these guidelines are only applicable to environmental health it is inappropriate to use them for assessment purposes in this study.

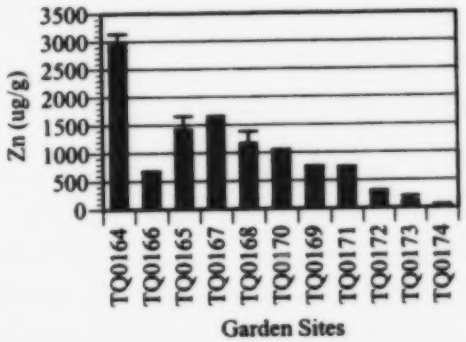

Figure 13. Mean Zn concentration (± SD, n = 3) in soil at each study site. Shading shows if the mean concentration was significantly higher (black), lower (gray), or not significantly different (white) than the mean concentration at TQ0174.

Chromium (Cr), Titanium (Ti), and Vanadium (V)

Soil quality guidelines and interim soil quality criteria also exist for several other elements that were analyzed in the soils collected from the garden sites. As mentioned previously, concentrations of Cr, Ti, and V were significantly higher in the Flin Flon soils than in the soil collected at the garden in The Pas. The soil quality guidelines for Cr for the protection of human health are 220 µg/g for agricultural and residential/parkland land use, and 630 µg/g and 2300 µg/g for commercial and industrial land use, respectively. The highest mean concentration of Cr was 50 µg/g at site TQ0171 (Table 3). Thus, none of the soil quality guidelines for Cr were exceeded at the sites in this study. Mean concentrations of Ti ranged from a low of 22 µg/g at the control site in The Pas to a high of 805 µg/g at site TQ0171 in Flin Flon (Table 3). The lowest mean concentration of Ti in Flin Flon was 355µg/g at site TQ0165. No soil quality guidelines or interim soil quality criteria have been established for Ti. Titanium is one of the most common elements in the earth's crust, and studies, although not numerous, indicate that Ti is probably only toxic to humans at extremely high concentrations (WHO 1982). An environmental protection guideline level for V of 130 µg/g for all land uses has been derived; however, a guideline value for human health protection has not been calculated. Mean concentrations of V ranged from 17 µg/g at the garden in The Pas to 47 µg/g at site TQ0171 in Flin Flon (Table 3). These concentrations are generally within the range of background levels reported for V in Canadian soils (CCME 1999).

Other Metals and Elements

Soil samples were also analyzed for total concentrations of Al, antimony (Sb), barium (Ba), beryllium (Be), boron (B), calcium (Ca), cobalt (Co), Fe, magnesium (Mg), manganese (Mn), molybdenum (Mo), Ni, phosphorus (P), potassium (K), sodium (Na), strontium (Sr), thallium (Tl), tin (Sn), and zirconium (Zr). The soil analysis results for these elements are found in Appendix 2.

Mean concentrations of Ba ranged from 100 µg/g at site TQ0173 in Cranberry Portage to 297 µg/g at sites TQ0164 and TQ0168 in Flin Flon. Although the highest concentrations of Ba were found in these two gardens in Flin Flon, mean concentrations of the element at several other Flin Flon sites were significantly lower than the mean concentration in the garden in The Pas. Soil quality guidelines for Ba for the protection of human health have not been calculated. However, general guidelines have been derived based on the interim assessment criteria. These guidelines vary from 750 µg/g for agricultural land uses to 500 µg/g in residential/parkland soils to 2000 µg/g in land intended for commercial and industrial use and were all well above levels found in the garden soils.

Mean concentrations of Ni ranged from <2 µg/g at site TQ0168 to 22 µg/g at site TQ0171 in Flin Flon. The mean concentration of Ni at most sites sampled did not vary significantly from the mean concentration of 19 µg/g recorded for the control site in The Pas. Soil quality guidelines for Ni for the protection of human health have not been calculated. A guideline of 50 µg/g for all land use classes has been derived for the protection of environmental health and is based on the negative effects of Ni on soil invertebrates, microbial activity, and plant growth (CCME 1999). This guideline was not exceeded in any of the soil samples collected.

The human health protection guideline for Tl in soil is 1 µg/g for all land use classes. Mean concentrations of Tl ranged from <0.1 µg/g at the site in Cranberry Portage to 0.3 µg/g at several sites in Flin Flon. Thus, the guideline was not exceeded at any of the gardens included in this study.

Mean concentrations of Co were relatively low and did not vary significantly between most sites sampled. Although soil quality guidelines have not yet been developed for Co, interim assessment and remediation criteria have been derived for the element. The highest mean concentration (7 µg/g) was recorded at sites TQ0165 and TQ0168 (both located in Flin Flon). This maximum concentration was below the interim assessment criterion for soil of 10 µg/g, and considerably lower than the interim remediation criteria for agricultural (40 µg/g), residential/parkland (50 µg/g), and commercial/industrial (300 µg/g) land use.

Boron concentrations ranged from 33 µg/g at site TQ0166 to 73 µg/g at site TQ0168. Soil quality guidelines have not been derived for B, and the interim assessment and remediation criteria that exist are based on hot water soluble B rather than (acid extracted) total B. However, since B is necessary for plant nutrition (Starr and Taggart 1987) and mean concentrations at most of the Flin Flon sites did not vary significantly from concentrations at the Cranberry Portage or The Pas sites, there is no concern for B levels in the garden soils.

Concentrations of Sb, Be, Mo, and Sn were below their respective laboratory detection limits in all soil samples, while elements such as Al, Fe, Ca, Mg, Mn, K, Na, Sr, P, and Zr were detected in most of the samples. Mean concentrations of these latter elements were generally quite variable and were not consistently elevated at the Flin Flon gardens when compared to the concentrations at the gardens in Cranberry Portage and The Pas. In fact, for several elements the concentrations at the Flin Flon sites were either not significantly different than those at Cranberry Portage and The Pas, or were significantly lower than concentrations at the sites in Cranberry Portage and The Pas. Soil quality guidelines and interim assessment and remediation criteria have not been developed for these elements.

Comparison with Past Studies

Summary statistics of the soil analysis results from the Pip (1991) study, the survey by HBM&S (1994), and the present study (Conservation) are presented in the series of graphs in Figure 14. Note that soil samples collected during the Pip study were only analyzed for Cd, Cu, and Pb, while samples collected during the HBM&S study were analyzed for As, Hg, and Zn, in addition to Cd, Cu, and Pb. The Pip data show the range and mean concentrations for each metal analyzed from the 12 gardens sampled in that study. According to Pip (1991), three replicate samples were collected from each site during the study. However, neither the raw data for these samples nor the summary statistics from each individual site were readily available to be used in this report (Pip pers. comm. 2002). Seven Flin Flon gardens and one garden in the neighbouring town of Creighton, SK, were sampled during the HBM&S study. A single composite soil sample was collected and analyzed from each site and the raw data were available from HBM&S (1994). Results from the Creighton site were not included in calculating the summary statistics used in Figure 14. The range and mean concentration data from the present study by Conservation were calculated using data from all 27 soil samples collected from the nine gardens located in Flin Flon, and did not include the data from sites in Cranberry Portage and The Pas.

The large standard deviations and wide ranges in concentrations in the three studies shows that there was not only variation in metal concentrations within each study, but, depending on the element, there was also considerable variation in concentrations between the different studies. The range in Cd concentrations and the mean Cd concentrations were relatively similar between the three studies. The range in Cu concentrations was wider in the present study than in the Pip and HBM&S studies. However, the mean Cu concentrations in the HBM&S study and the present study were quite similar, and both were higher than the Pip study. The ranges in Pb concentrations in the Pip and Conservation studies were similar to each other, while the range in Pb in the HBM&S study was much narrower and had a lower maximum than either of the other studies. This said, the mean Pb concentrations in the HBM&S and Conservation studies were comparable and both were lower than the Pip study. Concentrations of As, Hg, and Zn were more wide ranging in the Conservation study than in the HBM&S study. However, the standard deviations for each element tended to overlap between the two studies and therefore, mean concentrations of these elements were likely not significantly different between the two studies.

While cursory comparisons, such as those above, can be made between the soil data from the Pip and HBM&S studies and the present study, direct statistical comparison between the studies is difficult and likely invalid. First of all, different garden sites were used in all three studies, which introduces a great deal of variation into any statistical comparison. Differences in the location of plots relative to the smelter and differences in the soil type, number of years of exposure to smelter emissions, and gardening

practices at the plots all contributed to a high degree of variation in soil metal concentrations both within and between each of the studies. Statistical comparison between the study results is further hampered by the fact that the number of sites sampled, the sampling methods used, and the number of samples collected were not consistent between studies. Another difficulty in making comparisons between the data sets is that the summary statistics from the Pip study included data collected from gardens up to 12.8 km from the smelter, while the HBM&S and Conservation summary statistics were derived only from sites located in Flin Flon. This makes a direct comparison with the mean data from the Pip study problematic, especially since Pip (1991) reported that soil metal concentrations were inversely correlated with distance from the smelter.

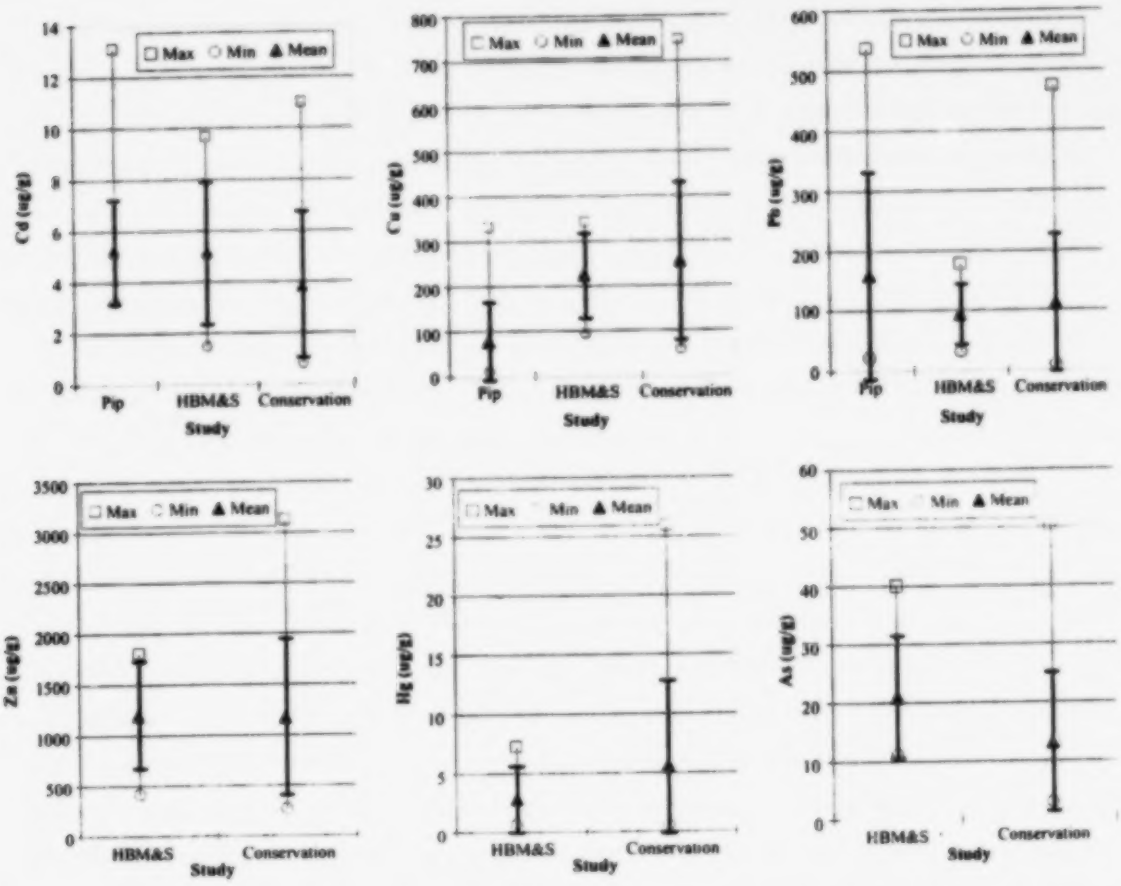

Figure 14. Mean (± SD) and range in metal concentrations in soil from Pip (1991) (n=36), HBM&S (1994) (n=7), and the present study (Conservation) (n=27).

Metals and Other Elements in Vegetation

General Results

Vegetable production was relatively robust at most of the gardens in this study and there was usually more than enough of each vegetable available for sampling at each site. Carrot production, although somewhat limited at a couple of the sites, was sufficient to provide three replicate samples from each garden. Potato production was also generally very good and three replicate samples were collected from each site except for garden site TQ0166, which only yielded enough material for a single sample. A total of 53 bean samples were collected from the eleven study sites. This included 29 samples that were washed and 24 samples that were left unwashed prior to analysis. Bean production at some sites was limited and as a result there was only enough material for three washed samples from site TQ0168 and a single washed sample from sites TQ0169 and TQ0172. No unwashed bean samples were available for analysis from these sites. A total of 63 lettuce samples were collected for analysis. Most sites yielded enough lettuce for three washed and three unwashed samples. However, lettuce production at site TQ0171 was relatively poor and material was only available for washed samples. A total of 58 tomato samples were collected for analysis. This included 31 washed samples and 27 unwashed samples. Tomato plants at site TQ0169 only yielded enough for one washed sample, and production was poor at site TQ0171 so only washed samples were collected.

Based on the concentrations of elements in the soil, the discussion of the analytical results for the vegetable samples will focus primarily on the metals As, Cd, Cu, Pb, Hg, Se, and Zn. Note that although the laboratory reported the vegetable metal concentration data on a dry weight basis, only fresh weight concentrations will be presented and discussed in this report. Fresh weight concentrations were calculated for each sample using the dry weight concentration and moisture content data. The moisture content of each sample and the dry weight concentrations for all elements analyzed in the vegetables are available in Appendix 3.

Arsenic (As)

Concentrations of As in potatoes and tomatoes were below detection at all sites sampled except site TQ0164 in Flin Flon (Figure 15, Table 5). Arsenic was above detection in carrot samples and washed bean samples collected from garden sites TQ0164, TQ0165, TQ0166, and TQ0167. Arsenic was also found in all of the washed lettuce samples, except those collected from the control site in The Pas. The element was more concentrated in lettuce than in the other crops at each site, with mean concentrations in washed lettuce samples in Flin Flon ranging from 0.03 µg/g at TQ0172 to 0.24 µg/g at site TQ0164. The

majority of washed lettuce samples had fresh weight concentrations of As above 0.05 µg/g, while concentrations in the other vegetables were almost always below 0.05 µg/g.

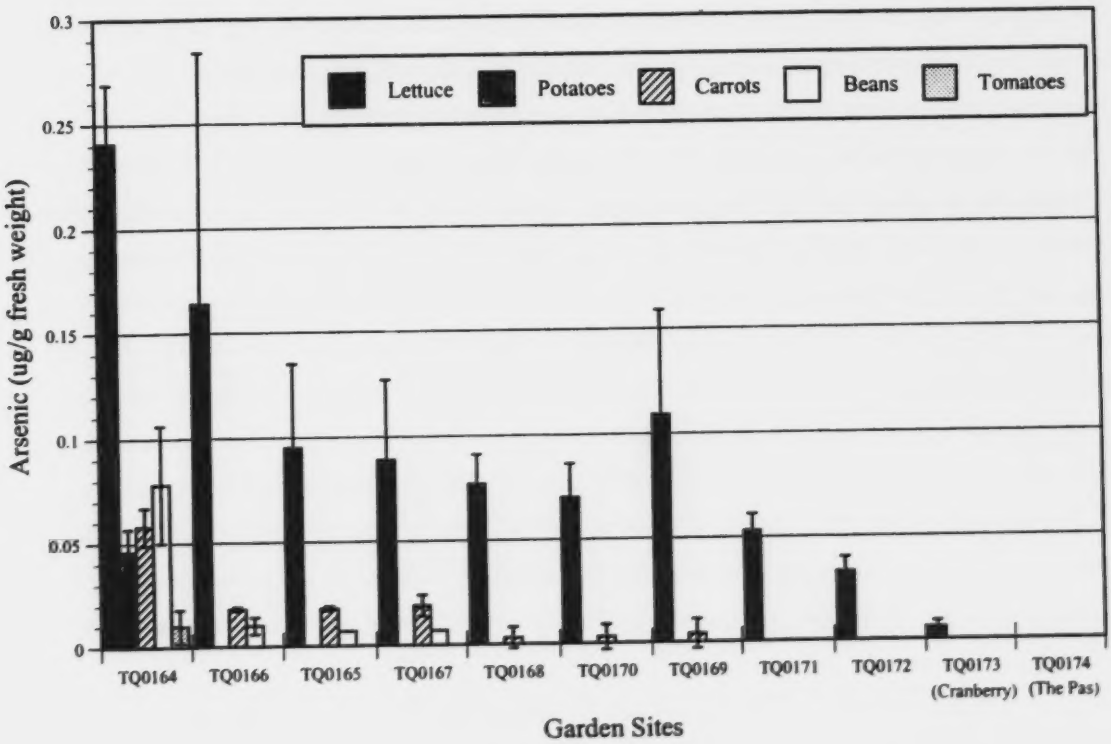

Figure 15. Arsenic concentration (µg/g fresh weight) in vegetable crops grown at each garden site. All crops were washed prior to analysis. Values are means ± SD. n = 3.

The relatively low concentrations of As in the washed carrot, potato, tomato, and bean samples, particularly when compared to the lettuce results, indicates that As was not as readily assimilated or stored in the edible portions of these vegetables. Xu and Thornton (1985) conducted a survey of garden vegetables grown in soil contaminated with As (range 144 - 892 µg/g) in Cornwall, England. They found that As was most concentrated in lettuce and that these concentrations were positively correlated with soil concentrations of the element, while concentrations in carrots and bean were lower and not related to soil concentrations. Statistical analysis of the lettuce data in the present study also showed a fairly strong positive correlation between As concentrations in the lettuce and As in the soil ($r = 0.73$). Correlation analysis between the As concentrations in the soil and the remaining vegetables was considered impractical because As concentrations in samples of these vegetables were usually less than detection.

This said, it is important to note that the highest As concentrations in tomatoes, potatoes, carrots, and beans were from samples collected at site TQ0164, which also had the highest soil As concentrations.

Table 5.. Arsenic concentrations (µg/g fresh weight) in unwashed and washed vegetable samples collected from the 11 study sites. Values are means (n = 3), except in cases where only one sample was available (see text). A p-value <0.05 indicates a significant difference (*t*-test) between mean concentrations of As in unwashed and washed samples of the same vegetable. (n/s = no sample available, < = less than laboratory detection limit).

Garden	Carrots	Potatoes	Beans			Tomatoes			Lettuce		
Site	washed	washed	unwashed	washed	p-value	unwashed	washed	p-value	unwashed	washed	p-value
TQ0164	0.06	0.05	0.08	0.08	0.8898	0.02	0.01	0.6624	0.99	0.24	**<0.0001**
TQ0166	0.02	<	0.01	0.01	0.1612	<	<		0.23	0.16	0.6523
TQ0165	0.02	<	0.01	0.01	**0.0140**	<	<		0.22	0.09	0.0688
TQ0167	0.02	<	0.01	0.01	0.1330	<	<		0.27	0.09	**0.0150**
TQ0168	<	<	n/s	<		<	<		0.18	0.08	**0.0009**
TQ0170	<	<	<	<		<	<		0.20	0.07	**0.0020**
TQ0169	<	<	n/s	<		n/s	<		0.29	0.11	**0.0115**
TQ0171	<	<	<	<		<	<		n/s	0.05	
TQ0172	<	<	n/s	<		n/s	<		0.09	0.03	**0.0011**
TQ0173	<	<	<	<		<	<		0.01	0.01	0.0907
TQ0174	<	<	<	<		<	<		0.03	<	

Arsenic concentrations from unwashed and washed lettuce, bean, and tomato samples were compared to determine if As had been deposited on the surface of the vegetables and to indicate whether washing was successful at reducing the amount of As in the vegetables. Unwashed vegetables were expected to have a higher concentration of As (and other elements) than washed vegetables because of potential surface deposition from smelter particulate emissions, road and other incidental dust in the area, tailings dust particles, and splashing of soil particles onto surfaces during watering and rainfall events.

The results of this comparison indicated that for most sites the washed lettuce samples had significantly lower As concentrations than samples that were not washed (Table 5). The higher As concentrations in the unwashed lettuce samples indicate that a significant amount of As had accumulated on the surface of lettuce leaves. Although the results do not indicate the exact source of the As, they do demonstrate that washing lettuce prior to consumption can significantly reduce the potential intake of As by consumers. The fact that there was still some As present in the lettuce leaves after washing indicates that As was either taken in by the roots and translocated to the leaves, or it was absorbed directly through the leaf surface. The installation of the higher smelter stack and recent improvements in pollution control mechanisms has significantly reduced the proportion of metal deposition within the community that comes directly from the smelter stack emissions. Thus, it is possible the As deposited on the surface

of the lettuce was predominantly from soil splash and dust particles rather than direct deposition from current smelter emissions. Furthermore, the relatively high correlation between As levels in the washed lettuce samples and levels in the soil suggests that As accumulation in these samples could be a result of combined uptake from the soil as well as absorption through leaves.

Washing did not result in a significant reduction in the total As concentration in beans or tomatoes (Table 5). This indicates that As did not accumulate on the surface of these vegetables, and further implies that the As that was present in the washed samples was likely incorporated via root uptake and translocation within the plant. The concentrations of As in beans were similar to results reported in Tlustos *et al.* (2002), who found that although bean plants did absorb As, the vast majority of the As that accumulated was taken up through the roots and not the leaves, pods, and seeds of the plant. Beans and tomatoes are fruiting bodies that develop gradually over the growing season. As such, the amount of time they are exposed to atmospheric deposition is limited when compared to lettuce leaves, which develop rapidly and have a relatively large surface area exposed over much of the growing season. Bean and tomato fruits are also usually shaded by plant foliage which limits the portion of their surface that is exposed to atmospheric deposition and splashing of soil particles.

Helgesen and Larsen (1998) and Samsoe-Petersen *et al.* (2002) compared As concentrations in peeled and non-peeled carrots and potatoes grown in As contaminated soil. They found that As levels were usually significantly higher in the non-peeled samples. This suggests that a portion of the total As in the carrot and potato samples from the present study may be adhering to or incorporated into the surface peel. Therefore, thorough cleaning with water followed by peel removal prior to cooking or consumption should reduce the potential for As ingestion when eating carrots and potatoes from Flin Flon gardens.

Koch *et al.* (2001) conducted a study to investigate As concentrations in garden vegetables in Yellowknife, NWT. Soils in the Yellowknife area contain elevated levels of As due to a combination of naturally high soil concentrations and deposition from local gold mining activities (RSSI 2001). The garden study was conducted as part of an overall assessment of the potential human health risk from exposure to As in Yellowknife. With the exception of beans, the concentration of As in vegetables sampled in the Yellowknife study were generally very comparable to levels recorded in the gardens in Flin Flon (Table 6). The higher range in concentration in beans grown in the Flin Flon gardens is due to the high concentrations reported from site TQ0164. Arsenic concentrations in beans from all the other gardens in Flin Flon were either below or only slightly above the detection limit.

Table 6. Range in As concentration of vegetables grown in gardens in Yellowknife, NWT (Koch *et al.* 2001) and in Flin Flon, MB.

Vegetable	Range in As Concentration (µg/g fresh weight) (n = number of gardens)	
	Yellowknife (2001)	Flin Flon (2002) (range of mean values)
Lettuce	0.06 – 0.27 (n = 3)	0.03 – 0.24 (n = 9)
Beans	0.016 – 0.026 (n = 3)	<0.01 - 0.08 (n =9)
Tomatoes	0.009 (n = 1)	<0.01 - 0.01 (n = 9)
Carrots	0.02 – 0.07 (n = 6)	<0.01 - 0.07 (n = 9)
Potatoes	<0.02 – 0.07 (n = 7)*	<0.01 - 0.05 (n = 9)

* includes white and red potatoes

The Joint Expert Committee on Food Additives (JECFA) has calculated a tolerable weekly intake (TWI) for inorganic As from all sources (FAO/WHO 2001) of 15 µg/kg/bw. This is equivalent to a tolerable daily intake (TDI) of inorganic As of 2.14 µg/kg/bw or 150 µg for a 70 kg adult. The total As concentration in vegetables collected from each study garden were used to calculate the amount of each vegetable that could be consumed without exceeding the TDI for inorganic As.

The first step in the calculation process was to obtain an estimate of the usual human daily intake of inorganic As from food, water, air, and soil. The estimated daily intake of inorganic As from supermarket foods by Canadians was obtained from Health Canada (1995a). Potential intake of As from Flin Flon soil was calculated using estimated human intake amounts for soil (CCME 1996) and the mean concentration of As in the 27 soil samples collected from the nine gardens in Flin Flon in 2002. Potential intake of As from soil in The Pas and Cranberry Portage was based on estimated human intake amounts for soil (CCME 1996) and mean As concentrations in the respective gardens of each community. Potential inhalation of As in Flin Flon air was determined using existing estimates of air intake rates for humans (Health Canada 1994a) and mean air quality data for the period 1988 - 2002 from the Main Street air quality monitoring station in Flin Flon (Regehr, pers. comm. 2004). Values for inhalation of As in air in The Pas and Cranberry Portage were estimated using data from Health Canada (1995a) and assumes that air in these communities is not contaminated with As. Ingestion of As from Flin Flon, The Pas, and Cranberry Portage drinking water was calculated using estimates of daily water intake by humans (Health Canada 1994a) and mean water quality data from treated water samples collected from each community for the period 1992 to 2001 (Chorniuk, pers. comm. 2004). All As in the soil, air, and water was assumed to be inorganic. The daily intake of As from these various sources was subtracted from the TDI. The result of this subtraction was then used to calculate the amount of each vegetable

from each garden site that would have to be consumed in order to exceed the TDI. The final values were calculated for several age/weight classes (see Table 7) and presented in Table 8.

Table 7. Age class/range and body weights used in calculating consumption amounts required to exceed the TDI for As. (Health Canada 1994a).

Age Class	Age Range	Weight (kg)
Infant	0 - 6 mths	7
Toddler	7 mths - 4 yrs	13
Child	5 - 11 yrs	27
Teen	12 - 19 yrs	57
Adult	20 - 70 yrs	70

Table 8. Amount (g) of each vegetable that could be consumed daily without exceeding the TDI for inorganic As. The amounts are for fresh vegetables and are over and above the daily intake of inorganic As from other sources such as food purchased from a grocery store, soil, air, and water. Consumption amounts were calculated only for those gardens which had samples with As concentrations above the laboratory detection limit.

Garden Site	Tolerable Daily Intake (ug/kg bw)	Vegetable	Amount (g) Required to Exceed Tolerable Daily Intake				
			Infant	Toddler	Child	Teen	Adult
TQ0164	2.14	Lettuce	46	85	200	462	575
TQ0166	2.14	Lettuce	68	125	295	681	847
TQ0165	2.14	Lettuce	118	216	510	1,178	1,467
TQ0167	2.14	Lettuce	125	229	540	1,248	1,554
TQ0168	2.14	Lettuce	146	266	629	1,453	1,809
TQ0170	2.14	Lettuce	160	293	691	1,596	1,987
TQ0169	2.14	Lettuce	103	187	443	1,022	1,272
TQ0171	2.14	Lettuce	211	386	911	2,104	2,620
TQ0172	2.14	Lettuce	335	613	1,447	3,340	4,159
TQ0173	2.14	Lettuce	2,152	3,919	8,855	19,913	24,727
TQ0164	2.14	Beans	142	260	615	1,420	1,767
TQ0166	2.14	Beans	1,130	2,066	4,879	11,266	14,027
TQ0165	2.14	Beans	1,632	2,982	7,041	16,260	20,245
TQ0167	2.14	Beans	1,506	2,753	6,501	15,011	18,690
TQ0164	2.14	Tomatoes	1,172	2,141	5,056	11,677	14,538
TQ0164	2.14	Carrots	191	349	825	1,905	2,372
TQ0166	2.14	Carrots	616	1,126	2,660	6,142	7,648
TQ0165	2.14	Carrots	632	1,155	2,727	6,298	7,841
TQ0167	2.14	Carrots	581	1,061	2,507	5,788	7,206
TQ0168	2.14	Carrots	4,202	7,679	18,133	41,873	52,134
TQ0170	2.14	Carrots	3,400	6,215	14,676	33,889	42,194
TQ0169	2.14	Carrots	2,634	4,814	11,367	26,249	32,681
TQ0164	2.14	Potatoes	245	447	1,056	2,438	3,036

Just as the concentration of As varied between vegetable species and between garden sites, the amount of each vegetable that could be consumed before exceeding the TDI also varied between sites and between vegetables (Table 8). Lettuce was the greatest accumulator of As and, as such, the consumption amounts required to exceed the TDI for inorganic As was lower for lettuce than for all other crops tested. Using site TQ0164 as an example, a toddler would be able to eat 85 g of lettuce, 260 g of beans, or 349 g of carrots each day before exceeding the TDI for inorganic As.

It must be emphasized that the results from site TQ0164 represent a worst case scenario for the gardens sampled in this study and the intake of As from eating vegetables grown at the other Flin Flon garden sites would be considerably lower than the intake from eating vegetables grown at TQ0164. The consumption amounts presented in Table 8 also assume that all of the As in the garden produce was inorganic As. The actual proportion of total As that is in inorganic form varies considerably between food groups (RSSI 2002). Yost *et al.* (1998) estimated that inorganic As accounts for approximately 47% of the total As content of commercially available vegetables and 75% of the total As content of commercially available potatoes. Furthermore, the average daily consumption of root and non-root vegetables by toddlers, children, teens, and adults in Canada (Table 9) are all below the allowable daily consumption amounts calculated for each vegetable in Table 8. Infants primarily consume breast milk, infant formula, and commercially prepared baby food, and thus As exposure from consumption of locally grown garden produce would likely not be a concern. According to Health Canada (1995b), backyard vegetables only account for about 7% of the total vegetable intake by Canadians (see Table 10). Therefore, assuming that this estimate is applicable to the population in Flin Flon, the actual amount of As intake from consumption of locally grown produce is expected to be relatively low. In fact, even if the total vegetable intake from Flin Flon gardens consisted entirely of lettuce, the amount of inorganic As ingested over the long-term would, depending on the source garden and the age class of the consumer, only account for between 1% and 10% of the TDI. Based on this interpretation of the data, it is concluded that the risk of acute or chronic toxicity from exposure to inorganic As through consumption of garden vegetables grown in Flin Flon is considered low. A similar conclusion was reached by Koch *et al.* (2001) in their study of As in vegetables grown in contaminated soil in Yellowknife, NWT.

Table 9. Estimated daily intake of vegetables by Canadians. Values are means from data on 'eaters only' (i.e. those reporting no consumption of the vegetable were not included in calculating the mean) (from Richardson 1997).

Vegetable Group	Estimated Daily Intake of Vegetables (g/day)				
	Infant	Toddler	Child	Teen	Adult
Root Vegetables*	83	105	161	227	188
Other Vegetables[1]	72	67	98	120	137
Total	155	172	259	347	325

Table 10. Estimated daily intake of vegetables by Canadians from backyard gardens. Values are calculated by using 7% (Health Canada 1995b) of total vegetable intake reported in Table 9

Vegetable Group	Estimated Daily Intake of Backyard Vegetables (g/day)				
	Infant	Toddler	Child	Teen	Adult
Root Vegetables*	6	7	11	16	13
Other Vegetables[1]	5	5	7	8	10
Total	11	12	18	24	23

* Root Vegetables includes carrots, onions, rutabagas, turnip, beets, and potatoes (raw, boiled, canned, French fries, chips)
[1] Other Vegetables includes corn, cabbage (and coleslaw), celery, green peppers, lettuce, cauliflower, broccoli, green beans, peas, tomatoes (fresh or canned, tomato-based condiments), mushrooms, cucumbers (fresh and cucumber-based condiments), baby food vegetables, asparagus, rhubarb, greens, squash, popcorn, and beans (white, beans with pork, etc.)

Inorganic As is classified as a carcinogen by Health Canada (Health Canada 1993). Epidemiological studies have shown that ingestion of inorganic As in drinking water and inhalation of inorganic As in air are linked to skin and lung cancer (respectively) in humans (Health Canada 1995a). A determination of the specific cancer risk posed by ingestion of vegetables grown in Flin Flon is beyond the scope of this study because more detailed site-specific environmental data would be required to make an accurate assessment. Results show that total As was elevated in some of the produce grown in Flin Flon when compared to the control plot in The Pas and that it varied considerably between gardens and between species. Lettuce and carrots accumulated various amounts of As, whereas most of the potato, tomato, and bean samples had concentrations below the laboratory detection limit. The data indicate that eating Flin Flon vegetables may increase the total intake and exposure to inorganic As by consumers which may in turn increase the risk of skin cancer. However, it must be kept in mind that cancer risk assessments are very conservative, are based on constant exposure over a period of 70 years, and likely overestimate the actual number of cancer cases that may occur (EPA 1989).

Cadmium (Cd)

Cadmium was detected in all vegetable samples collected in this study. Mean concentrations were highest in lettuce, while potatoes and beans tended to have the lowest concentrations (Figure 16, Table 11). Concentrations in carrots and tomatoes were only slightly higher than concentrations in potatoes and beans. Mean concentrations of Cd in most vegetables grown in Flin Flon were significantly higher than concentrations in vegetables grown in Cranberry Portage and The Pas. Exceptions to this were the tomatoes and potatoes from site TQ0172. Mean concentrations of Cd in washed lettuce samples ranged from 0.02 µg/g at the Cranberry Portage garden to 0.78 µg/g at site TQ0164 in Flin Flon. The lowest mean concentration in lettuce grown in Flin Flon was 0.15 µg/g in samples from site TQ0172, which was still significantly higher than concentrations in lettuce from gardens in Cranberry Portage and The Pas.

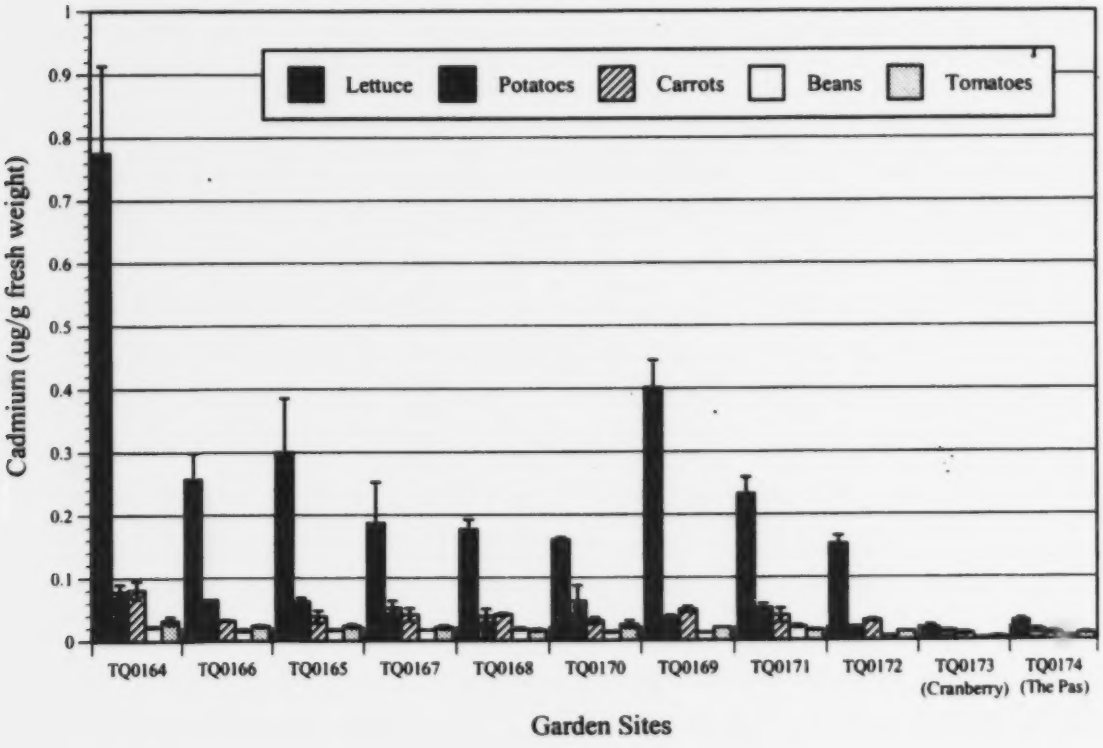

Figure 16. Cadmium concentration (µg/g fresh weight) in vegetable crops grown at each garden site. All crops were washed prior to analysis. Values are means ± SD. n = 3.

Several studies have shown that leafy vegetables such as lettuce are relatively tolerant of Cd and tend to accumulate the metal at much higher concentrations than other vegetables (Jinadasa *et al.* 1997, Logan *et al.* 1997, Lehoczky *et al.* 1998, Wang 2002). Furthermore, the ability of plants to accumulate Cd without experiencing any toxic effects varies considerably between different vegetable species and even between different cultivars of the same vegetable species (Ramos *et al.* 2002). Thus, it was not surprising that of the five vegetable crops grown in Flin Flon, the highest Cd concentrations were found in lettuce. Work by Ferguson 1990 (referenced in Jinadasa *et al.* 1997) showed that Cd accumulation in plants tended to be highest in the roots and stems, followed by the leaves and finally the fruit and seeds. This suggests that although Cd concentrations in beans and tomatoes (which are both fruits with seeds) from Flin Flon were relatively low, concentrations in the stem, roots and leaves of these species may have been significantly higher.

Table 11. Cadmium concentrations (µg/g fresh weight) in unwashed and washed vegetable samples collected from the 11 study sites. Values are means (n = 3) except in cases where only one sample was available (see text). A p-value <0.05 indicates a significant difference (*t*-test) between mean concentrations of Cd in unwashed and washed samples of the same vegetable. (n/s = no sample available).

Garden	Carrots	Potatoes	Beans			Tomatoes			Lettuce		
Site	washed	washed	unwashed	washed	p-value	unwashed	washed	p-value	unwashed	washed	p-value
TQ0164	0.08	0.08	0.03	0.02	0.0562	0.03	0.03	0.6413	1.01	0.78	**0.0414**
TQ0166	0.03	0.07	0.02	0.02	0.7637	0.02	0.02	0.9672	0.28	0.26	0.8176
TQ0165	0.04	0.06	0.02	0.02	0.1516	0.02	0.02	0.9994	0.39	0.30	0.2279
TQ0167	0.04	0.05	0.02	0.02	**0.0507**	0.02	0.02	0.5642	0.28	0.19	0.2035
TQ0168	0.04	0.04	n/s	0.02		0.02	0.02	0.9471	0.22	0.18	**0.0114**
TQ0170	0.03	0.06	0.01	0.01	0.8493	0.03	0.02	0.7958	0.20	0.16	0.0898
TQ0169	0.05	0.04	n/s	0.01		n/s	0.02		0.52	0.40	0.0833
TQ0171	0.04	0.05	0.02	0.02	0.3139	0.02	0.02	0.3241	n/s	0.23	
TQ0172	0.03	0.02	n/s	0.01		n/s	0.01		0.18	0.15	0.1347
TQ0173	0.01	0.01	0.00	0.00	0.8524	0.00	0.00	0.5077	0.02	0.02	0.6953
TQ0174	0.01	0.02	0.00	0.00	0.4679	0.01	0.01	0.8500	0.04	0.03	0.1738

Cadmium concentrations in the washed lettuce samples were very highly correlated with levels in the soil ($r = 0.858$), implying that the amount of cadmium in the soil had a strong influence on the amount of Cd taken in and accumulated by the lettuce plants. Szomolanyi and Lehoczky (2002) indicated that lettuce is able to accumulate Cd to levels (dry weight) considerably higher than concentrations in the soil. This was evident in the present study, which had dry weight concentrations of Cd in washed lettuce samples approaching and, in some cases, exceeding the concentration of the element in the soil. The concentrations of Cd in the potato and carrot samples were also highly correlated with the amount of Cd

in the soil (r = 0.797 and 0.798, respectively), while Cd concentrations in beans and tomatoes and concentrations in the soil were more moderately correlated (r = 0.456 and 0.593, respectively). The tendency for Cd to be more readily accumulated in roots, stems, and leaves than in fruits and seeds (Ferguson 1990 as referenced in Jinadasa *et al.* 1997) may account for the variation in degree of correlation.

In general, washing tomatoes, beans, and lettuce samples did not significantly reduce the amount of Cd in each vegetable (Table 11). Although the mean concentrations of Cd in the washed vegetables were often less than mean concentrations in the unwashed samples, this difference was only significant in bean samples from site TQ0167 and lettuce samples from sites TQ0164 and TQ0168. These results suggest that there was either little or no Cd deposition onto the surface of these vegetables or that the Cd that was deposited was quickly absorbed through the vegetable surface. Similar to the case with As, studies have shown that Cd is more concentrated in the peel of carrots and potatoes than in the tissues beneath the peel (Logan *et al.* 1997, Dudka and Miller 1999, Samsoe-Petersen *et al.* 2002). Therefore, thorough washing and peeling of root and rhizomatous vegetables should help to reduce the intake of Cd by the consumer.

The JECFA recommended TWI for Cd is 7 µg/kg/bw from all sources (FAO/WHO 2001). This is equivalent to a TDI of 1 µg/kg/bw or a daily total of 70 µg for a 70 kg adult. The total Cd concentrations in vegetables (fresh weight) were used to calculate the amount of each vegetable from each garden site that could be consumed before exceeding the TDI for Cd. This amount was calculated for several different age/weight classes. Total daily intake of Cd from all sources was estimated using dietary intake values reported in Health Canada (1994b) plus information gleaned from Flin Flon soil, water, and air quality data. The daily intake of Cd from these various sources was subtracted from the TDI and the result was used to calculate the maximum amount of each vegetable from each site that could be eaten without exceeding the TDI.

The amount of each vegetable that could be consumed without exceeding the TDI for Cd varied considerably between sites and between vegetables (Table 12). Since lettuce had the highest concentrations of Cd, it follows that the amount of lettuce one could consume without exceeding the TDI for Cd was low compared to the other vegetables in this study. Using site TQ0164 as a worst case scenario, a toddler would have to eat 5 g of lettuce each day in order to exceed the TDI for Cd. An adult weighing 70 kg would have to consume over 68 g of lettuce (Figure 17) from site TQ0164 in order to exceed the TDI for Cd. This amount is considerably higher than the average total intake of 23 g from all backyard garden vegetables (Table 10).

Table 12. Amount (g) of each vegetable that could be consumed daily without exceeding the TDI for Cd. The amounts are for fresh vegetables and are over and above the daily intake of Cd from other sources such as food purchased from a grocery store, soil, air, and water.

Garden Site	Tolerable Daily Intake (ug/kg bw)	Vegetable	Amount (g) Required to Exceed Tolerable Daily Intake				
			Infant	Toddler	Child	Teen	Adult
TQ0164	1	Lettuce	3	5	15	50	68
TQ0166	1	Lettuce	8	14	45	150	206
TQ0165	1	Lettuce	7	12	39	128	177
TQ0167	1	Lettuce	10	19	62	205	283
TQ0168	1	Lettuce	11	20	66	217	299
TQ0170	1	Lettuce	12	22	73	240	331
TQ0169	1	Lettuce	5	9	29	96	132
TQ0171	1	Lettuce	8	15	50	165	227
TQ0172	1	Lettuce	13	23	77	252	348
TQ0173	1	Lettuce	122	224	665	2,073	2,840
TQ0174	1	Lettuce	70	135	416	1,311	1,799
TQ0164	1	Beans	89	163	534	1,756	2,423
TQ0166	1	Beans	121	219	720	2,368	3,267
TQ0165	1	Beans	117	214	701	2,306	3,182
TQ0167	1	Beans	113	206	675	2,220	3,062
TQ0168	1	Beans	108	197	645	2,122	2,927
TQ0170	1	Beans	149	272	892	2,932	4,045
TQ0169	1	Beans	164	298	977	3,212	4,432
TQ0171	1	Beans	92	167	548	1,801	2,485
TQ0172	1	Beans	335	609	2,001	6,580	9,078
TQ0173	1	Beans	861	1,584	4,708	14,678	20,107
TQ0174	1	Beans	464	893	2,749	8,666	11,890
TQ0164	1	Tomatoes	62	112	368	1,208	1,667
TQ0166	1	Tomatoes	84	154	504	1,658	2,287
TQ0165	1	Tomatoes	86	156	513	1,685	2,325
TQ0167	1	Tomatoes	92	167	547	1,800	2,483
TQ0168	1	Tomatoes	119	217	712	2,340	3,229
TQ0170	1	Tomatoes	80	145	475	1,561	2,154
TQ0169	1	Tomatoes	100	181	596	1,959	2,703
TQ0171	1	Tomatoes	120	218	715	2,349	3,241
TQ0172	1	Tomatoes	146	265	871	2,864	3,951
TQ0173	1	Tomatoes	554	1,019	3,029	9,443	12,936
TQ0174	1	Tomatoes	208	401	1,235	3,891	5,339
TQ0164	1	Carrots	24	44	144	473	653
TQ0166	1	Carrots	61	112	366	1,204	1,662
TQ0165	1	Carrots	52	94	309	1,016	1,402
TQ0167	1	Carrots	47	86	282	926	1,278
TQ0168	1	Carrots	48	87	286	942	1,299
TQ0170	1	Carrots	64	116	380	1,249	1,724
TQ0169	1	Carrots	40	72	238	782	1,078
TQ0171	1	Carrots	50	92	301	988	1,364
TQ0172	1	Carrots	63	115	378	1,241	1,712
TQ0173	1	Carrots	227	418	1,241	3,870	5,302
TQ0174	1	Carrots	186	359	1,104	3,480	4,775
TQ0164	1	Potatoes	25	46	150	495	683
TQ0166	1	Potatoes	30	55	179	589	813
TQ0165	1	Potatoes	31	57	188	617	851
TQ0167	1	Potatoes	38	69	226	744	1,026
TQ0168	1	Potatoes	51	94	307	1,010	1,394
TQ0170	1	Potatoes	32	58	189	621	857
TQ0169	1	Potatoes	55	101	330	1,085	1,497
TQ0171	1	Potatoes	38	69	228	749	1,033
TQ0172	1	Potatoes	99	180	590	1,941	2,678
TQ0173	1	Potatoes	169	311	923	2,878	3,943
TQ0174	1	Potatoes	141	271	833	2,626	3,604

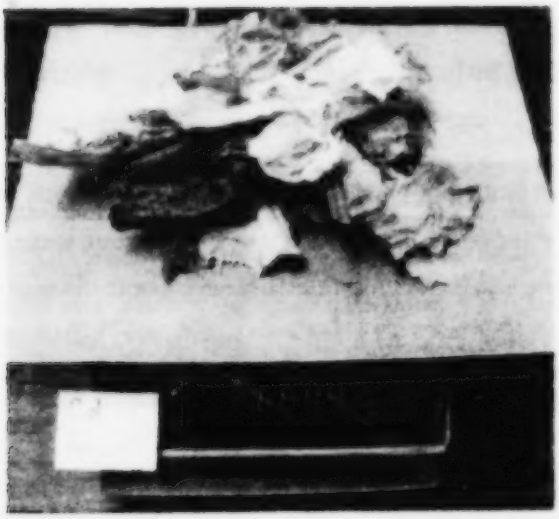

Figure 17. Approximate amount of fresh lettuce a 70 kg adult could consume daily from site TQ0164 without exceeding the TDI for Cd.

Assuming a toddler eats an average of 12 g of garden vegetables per day (Table 10), and that the vegetable intake from Flin Flon gardens consisted entirely of lettuce, then the amount of Cd ingested over the long-term by toddlers would be between 2% and 72% of the TDI depending on the source garden. The low end of this range is for lettuce from site TQ0173, while the high end of the range is for lettuce from site TQ0164. Again, site TQ0164 represents the worst case scenario. The amount of Cd ingested from the remaining gardens would, at most, be 37% of the TDI. The amount of Cd ingested by toddlers under the scenario of lettuce as the sole non-root vegetable would range between 1% and 28% of the TDI, with lettuce from the majority of gardens in this range contributing less than 15% of the TDI. Assuming the entire vegetable intake from gardens was lettuce, the amount of Cd ingested over the long-term by adults would amount to between 1% and 25% of the TDI for this age group. Again, lettuce from TQ0164 represents a worst case scenario and consumption of lettuce from the other gardens would contribute significantly less to the TDI for Cd.

Although lettuce tended to accumulate relatively high amounts of Cd, locally grown lettuce likely makes up only a small portion of the total lettuce consumed (owing to the relatively short growing season). Thus, the health risk from exposure to Cd in lettuce grown in Flin Flon gardens is considered low. Cadmium accumulations in the other vegetables in this study were significantly lower than in lettuce. As such, the amount of each vegetable that would have to be consumed in order to exceed the TDI for Cd was generally much higher than the usual daily intake of these vegetables (Table 12), and the

health risk associated with exposure to Cd from eating these vegetables is considered to be extremely low.

Copper (Cu)

Copper was detected in all of the vegetable samples submitted for analysis. Copper concentrations tended to be highest in lettuce and potato samples and lowest in the bean, tomato, and carrot samples at most of the Flin Flon sites sampled (Fig. 18, Table 13). Mean concentrations of Cu in lettuce from the Flin Flon sites ranged from 1.1 µg/g to 4.7 µg/g and were significantly higher than the concentrations recorded at the gardens in Cranberry Portage and The Pas. Like lettuce, mean concentrations in potatoes also tended to be higher at the Flin Flon sites; however, the differences were usually less pronounced and not always statistically significant. Copper concentrations in beans, tomatoes, and carrots were usually less than 1 µg/g, and in most cases the levels in vegetables from Flin Flon were not significantly higher than in vegetables grown in the gardens in The Pas and Cranberry Portage.

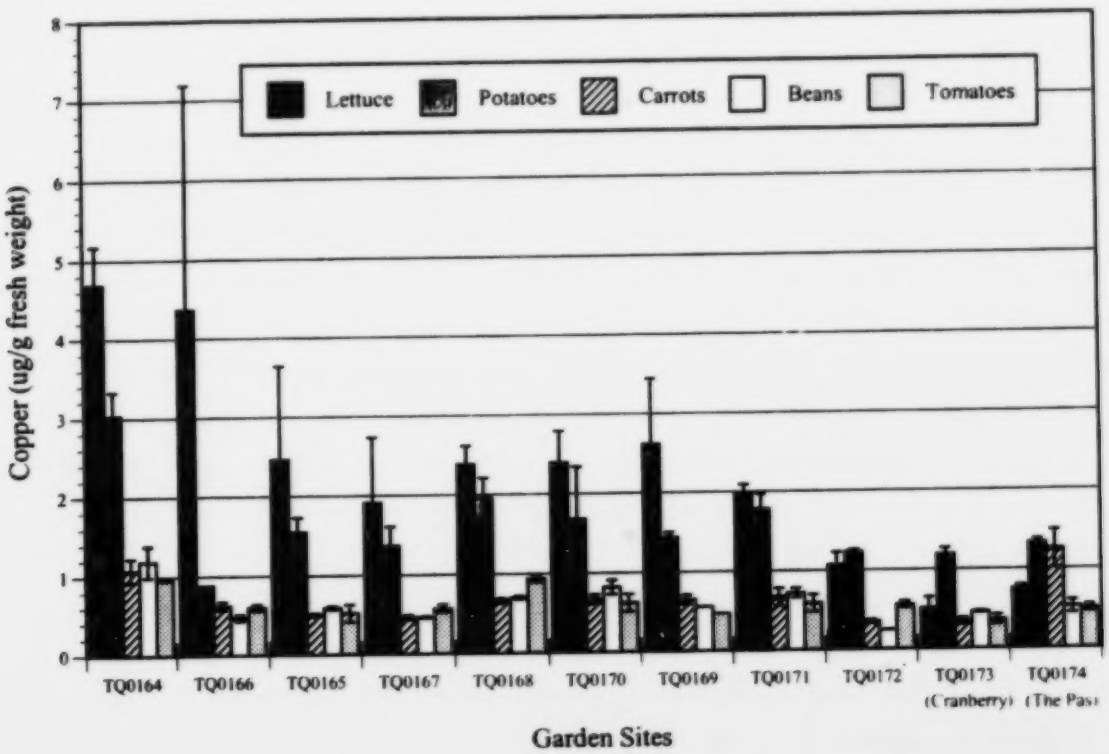

Figure 18. Copper concentration (µg/g fresh weight) in vegetable crops grown at each garden site. All crops were washed prior to analysis. Values are mean ± SD. n = 3.

There was no significant difference between the amount of Cu in washed and unwashed tomatoes (Table 13). This indicates that either Cu was not deposited on the surface of the vegetable or that, if deposition occurred, the element was readily absorbed through the vegetable surface. Similar results were observed when comparing washed and unwashed bean samples. Results from the lettuce samples, however, indicated that Cu accumulated on the lettuce grown in Flin Flon gardens and that washing significantly reduced the overall Cu content of the lettuce. These latter results are similar to the results for As and suggest that atmospheric deposition of metals onto lettuce was occurring in Flin Flon. The results do not, however, indicate whether the source of the deposition is from splashing of soil particles, road or other incidental dust in the area, dust from the tailings impoundment area, or fall out from present smelter emissions.

Statistical analysis showed that Cu concentrations in washed potatoes were positively correlated with Cu concentrations in the soil ($r = 0.761$). The correlation between Cu concentrations in washed bean samples and the soil was somewhat weaker ($r = 0.651$), while the strength of the correlations between concentrations in washed samples of carrots, lettuce, and tomatoes and the soil was relatively moderate ($r = 0.544$, $r = 0.544$, and $r = 0.502$, respectively).

Table 13. Copper concentrations (µg/g fresh weight) in unwashed and washed vegetable samples collected from the 11 study sites. Values are means (n = 3) except in cases where only one sample was available (see text). A p-value <0.05 indicates a significant difference (*t*-test) between mean concentrations of Cu in unwashed and washed samples of the same vegetable. (n/s = no sample available).

Garden	Carrots	Potatoes	Beans			Tomatoes			Lettuce		
Site	washed	washed	unwashed	washed	p-value	unwashed	washed	p-value	unwashed	washed	p-value
TQ0164	1.1	3.0	1.2	1.2	0.9115	1.0	1.0.	0.5198	19.0	4.7	**<0.0001**
TQ0166	0.6	0.9	0.5	0.5	0.4184	0.7	0.6	0.1684	5.6	4.4	0.7016
TQ0165	0.5	1.6	0.7	0.6	**0.0138**	0.6	0.5	0.6336	6.1	2.5	0.0570
TQ0167	0.5	1.4	0.5	0.5	**0.0064**	0.6	0.6	0.5214	5.3	1.9	**0.0228**
TQ0168	0.7	2.0	n/s	0.7		0.9	0.9	0.8417	5.9	2.4	**0.0001**
TQ0170	0.7	1.7	0.9	0.8	0.5745	0.7	0.6	0.6796	6.2	2.4	**0.0018**
TQ0169	0.7	1.4	n/s	0.6		n/s	0.5		7.0	2.6	**0.0043**
TQ0171	0.7	1.8	0.7	0.7	0.8878	0.6	0.6	0.8879	n/s	2.0	
TQ0172	0.3	1.2	n/s	0.2		n/s	0.6		2.4	1.1	**0.0008**
TQ0173	0.3	1.2	0.4	0.5	0.0529	0.4	0.4	0.9932	0.4	0.5	0.2322
TQ0174	1.2	1.3	0.5	0.5	0.8191	0.5	0.5	0.1842	0.8	0.7	0.4772

The JECFA suggests a TWI for Cu from all sources of 3500 µg/kg/bw (FAO/WHO 2001). This is equivalent to a TDI of 500 µg/kg/bw or 35 mg of Cu per day for a 70 kg adult. The total Cu concentrations in vegetables (fresh weight) were used to calculate the amount of each vegetable from each site that could be consumed without exceeding the TDI for Cu. This amount was calculated for

several different age/weight classes. The total daily intake of Cu from all sources was arrived at using estimates of intake from supermarket foods by Canadians (CCME 1997) plus information gleaned from Flin Flon soil, water, and air quality data. This estimated value was then subtracted from the TDI and the result was used to calculate the maximum amount of each vegetable from each site that could be consumed without exceeding the TDI for Cu.

Lettuce and potatoes tended to accumulate the highest concentrations of Cu, and thus the consumption amounts required to exceed the TDI were generally lower for lettuce and potatoes than all other vegetables (Table 14). The amount of each vegetable that could be consumed without exceeding the TDI is quite high for all sites sampled, including site TQ0164 in Flin Flon. Using the data from TQ0164 as an example, a toddler would have to eat over 1 kg of lettuce or almost 2 kg of potatoes (Figure 19), while a 70 kg adult would have to consume over 7 kg of lettuce or 11 kg of potatoes each day before exceeding the TDI for Cu. Since these amounts are well in excess of the usual daily intake of these vegetables by toddlers and adults, the health risk from exposure to Cu in lettuce and potatoes grown in Flin Flon gardens is considered to be extremely low.

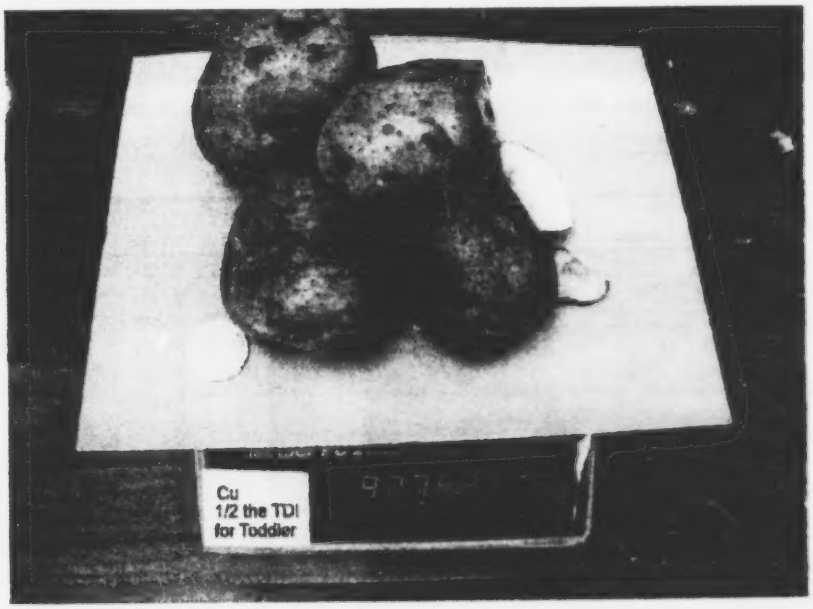

Figure 19. A 13 kg toddler could consume approximately twice the amount of potatoes pictured above from site TQ0164 without exceeding the TDI for Cu.

Table 14. Amount (g) of each vegetable that could be consumed daily without exceeding the TDI for Cu. The amounts are for fresh vegetables and are over and above the daily intake of Cu from other sources such as food purchased from a grocery store, soil, air, and water.

Garden Site	Tolerable Daily Intake (ug/kg bw)	Vegetable	Amount (g) Required to Exceed Tolerable Daily Intak				
			Infant	Toddler	Child	Teen	Adult
TQ0164	500	Lettuce	629	1,199	2,603	5,738	7,142
TQ0166	500	Lettuce	674	1,286	2,792	6,155	7,660
TQ0165	500	Lettuce	1,199	2,287	4,965	10,944	13,621
TQ0167	500	Lettuce	1,547	2,951	6,406	14,122	17,575
TQ0168	500	Lettuce	1,236	2,359	5,119	11,285	14,045
TQ0170	500	Lettuce	1,235	2,357	5,115	11,276	14,033
TQ0169	500	Lettuce	1,129	2,155	4,677	10,310	12,832
TQ0171	500	Lettuce	1,491	2,845	6,174	13,611	16,940
TQ0172	500	Lettuce	2,745	5,236	11,364	25,053	31,180
TQ0173	500	Lettuce	5,773	11,031	23,895	52,592	65,445
TQ0174	500	Lettuce	3,953	7,555	16,366	36,019	44,822
TQ0164	500	Beans	2,471	4,714	10,230	22,552	28,068
TQ0166	500	Beans	6,207	11,843	25,703	56,662	70,520
TQ0165	500	Beans	5,028	9,592	20,818	45,893	57,116
TQ0167	500	Beans	6,443	12,292	26,678	58,811	73,193
TQ0168	500	Beans	4,240	8,089	17,555	38,701	48,165
TQ0170	500	Beans	3,604	6,877	14,925	32,901	40,947
TQ0169	500	Beans	5,280	10,074	21,864	48,198	59,986
TQ0171	500	Beans	4,078	7,779	16,884	37,221	46,324
TQ0172	500	Beans	12,277	23,422	50,834	112,065	139,471
TQ0173	500	Beans	6,408	12,243	26,521	58,371	72,638
TQ0174	500	Beans	5,662	10,821	23,439	51,587	64,195
TQ0164	500	Tomatoes	3,050	5,820	12,631	27,845	34,654
TQ0166	500	Tomatoes	4,910	9,367	20,330	44,818	55,778
TQ0165	500	Tomatoes	5,715	10,903	23,663	52,166	64,923
TQ0167	500	Tomatoes	5,156	9,838	21,352	47,070	58,581
TQ0168	500	Tomatoes	3,134	5,979	12,976	28,606	35,602
TQ0170	500	Tomatoes	4,732	9,027	19,592	43,191	53,754
TQ0169	500	Tomatoes	6,303	12,025	26,097	57,532	71,602
TQ0171	500	Tomatoes	4,958	9,460	20,531	45,260	56,328
TQ0172	500	Tomatoes	5,219	9,958	21,612	47,643	59,295
TQ0173	500	Tomatoes	8,126	15,526	33,632	74,024	92,116
TQ0174	500	Tomatoes	5,889	11,253	24,376	53,649	66,761
TQ0164	500	Carrots	2,731	5,210	11,307	24,926	31,022
TQ0166	500	Carrots	4,784	9,127	19,808	43,668	54,347
TQ0165	500	Carrots	5,954	11,359	24,652	54,346	67,637
TQ0167	500	Carrots	6,364	12,141	26,351	58,091	72,297
TQ0168	500	Carrots	4,438	8,468	18,378	40,515	50,423
TQ0170	500	Carrots	4,389	8,374	18,175	40,067	49,866
TQ0169	500	Carrots	4,529	8,640	18,752	41,339	51,449
TQ0171	500	Carrots	4,371	8,340	18,100	39,902	49,661
TQ0172	500	Carrots	8,530	16,273	35,319	77,860	96,902
TQ0173	500	Carrots	8,619	16,468	35,672	78,513	97,701
TQ0174	500	Carrots	2,368	4,525	9,803	21,575	26,848
TQ0164	500	Potatoes	973	1,856	4,029	8,882	11,054
TQ0166	500	Potatoes	3,361	6,413	13,919	30,684	38,188
TQ0165	500	Potatoes	1,901	3,628	7,874	17,357	21,602
TQ0167	500	Potatoes	2,153	4,108	8,916	19,654	24,461
TQ0168	500	Potatoes	1,504	2,870	6,230	13,733	17,092
TQ0170	500	Potatoes	1,754	3,347	7,265	16,015	19,932
TQ0169	500	Potatoes	2,048	3,908	8,481	18,696	23,268
TQ0171	500	Potatoes	1,658	3,163	6,865	15,135	18,836
TQ0172	500	Potatoes	2,405	4,589	9,960	21,956	27,325
TQ0173	500	Potatoes	2,489	4,756	10,301	22,673	28,215
TQ0174	500	Potatoes	2,217	4,238	9,179	20,202	25,140

Lead (Pb)

Lettuce accumulated the highest concentrations of Pb among the vegetables grown in this study (Figure 20, Table 15). Mean levels of Pb in fresh, washed lettuce samples ranged from below detection at the garden in The Pas to 0.67 µg/g at site TQ0164 in Flin Flon. Lead concentrations were significantly higher in lettuce grown in Flin Flon gardens than in lettuce from the gardens in Cranberry Portage and The Pas. Levels of Pb in most of the other vegetables were less than 0.05 µg/g, and in many cases the Pb levels in these vegetables were below the laboratory detection limit. It is not known why the concentration of Pb was elevated (0.1 µg/g) in washed bean samples from the garden in The Pas, but was barely above the detection limit in unwashed bean samples from the same site.

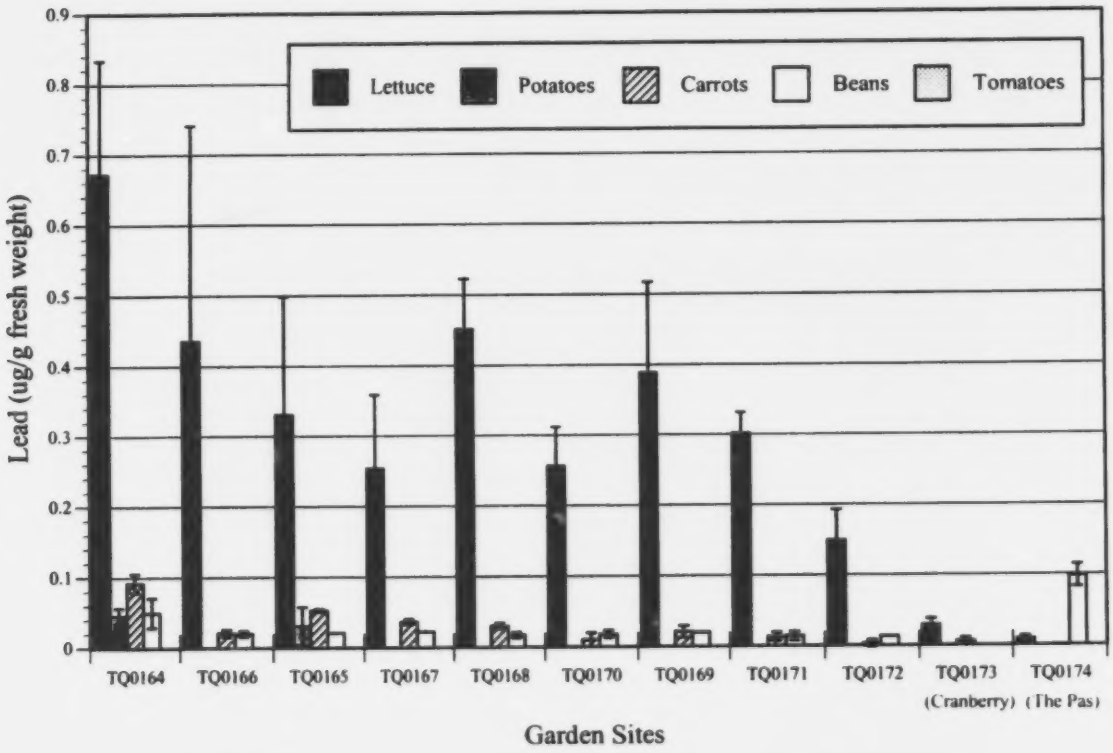

Figure 20. Lead concentration (µg/g fresh weight) in vegetable crops grown at each garden site. All crops were washed prior to analysis. Values are means ± SD. n = 3.

All washed lettuce samples had lower mean concentrations of Pb than the unwashed samples (Table 15). Thus, as with As and Cu, it appears that Pb was deposited onto the surface of the lettuce leaves while they were growing. This also indicates that washing lettuce prior to eating will reduce the amount

of Pb intake by the consumer. The fact that there were still detectable amounts of Pb in the lettuce after washing indicates that the plants were taking in the metal—either via the roots or the leaf surface, or a combination of both. A correlation coefficient (r value) of 0.496 suggests only a moderate relationship between Pb concentrations in the washed lettuce and the soil, and implies that a portion of the Pb intake was likely via leaf absorption. Samsoe-Petersen *et al.* (2002) investigated uptake of metals by vegetables grown in soil of varying degrees of contamination. The soil used in their study was removed from the contaminated sites and transferred to a different location away from any obvious sources of atmospheric deposition. They found that concentrations of Pb in carrots and potatoes, when grown in moderately and heavily contaminated soils (mean Pb concentrations of 130 µg/g and 997 µg/g, respectively), tended to be higher than concentrations in lettuce and beans. The Pb concentrations in carrots and potatoes from our study were similar to those reported by Samsoe-Peterson *et al.* (2002). However, our study showed that concentrations of Pb in lettuce were not only considerably higher than concentrations in carrots and potatoes, but were also orders of magnitude higher than those reported for lettuce in the Samsoe-Petersen *et al.* (2002) study, even though soil concentrations of Pb in Flin Flon were within the range of the moderately contaminated soil used in their study. The inconsistency between studies suggests that a significant portion of the Pb in the lettuce grown in Flin Flon was absorbed through the leaves following atmospheric deposition.

Table 15. Lead concentrations (µg/g fresh weight) in unwashed and washed vegetable samples collected from the 11 study sites. Values are means (n = 3) except in cases where only one sample was available (see text). A p-value <0.05 indicates a significant difference (*t*-test) between mean concentrations of Pb in unwashed and washed samples of the same vegetable. (n/s = no sample available).

Garden	Carrots	Potatoes	Beans			Tomatoes			Lettuce		
Site	washed	washed	unwashed	washed	p-value	unwashed	washed	p-value	unwashed	washed	p-value
TQ0164	0.09	0.05	0.07	0.05	0.1941	0.02	<		2.86	0.67	**0.0002**
TQ0166	0.02	<	0.03	0.02	0.1473	0.01	<		0.65	0.44	0.5768
TQ0165	0.05	0.03	0.03	0.02	0.0955	0.01	<		1.06	0.33	0.0758
TQ0167	0.04	<	0.03	0.02	**<0.0001**	<	<		1.13	0.25	**0.0449**
TQ0168	0.03	<	n/s	0.02		<	<		1.21	0.45	**0.0002**
TQ0170	0.01	<	0.03	0.02	0.2734	0.01	<		0.73	0.26	**0.0038**
TQ0169	0.02	<	n/s	0.02		n/s	<		1.01	0.39	**0.0084**
TQ0171	0.01	<	0.02	0.01	0.2716	<	<		n/s	0.30	
TQ0172	<	<	n/s	0.01		n/s	<		0.36	0.15	**0.0045**
TQ0173	0.01	<	<	<		<	<		0.06	0.03	0.0602
TQ0174	<	<	0.02	0.10	**0.0075**	<	<		0.04	0.01	**0.0040**

The JECFA TWI for Pb is 25 µg/kg/bw from all sources (FAO/WHO 2001). This equates to a TDI of approximately 3.57 µg/kg/bw or a daily total of 250 µg of Pb for an adult weighing 70 kg. As with the

previous metals, the total Pb concentration data from each site were used to estimate the amount of each vegetable (fresh weight) that could be eaten without exceeding the TDI for Pb. The daily dietary intake of Pb for Canadians from supermarket foods was gleaned from information in Dabeka and McKenzie (1995). These data and estimates of exposure to Pb using Flin Flon soil, water, and air quality data were summed to give a total daily intake of Pb from all sources. This intake value was then subtracted from the TDI and the result was used to calculate the amount of each vegetable from each site that could be consumed without exceeding the TDI for Pb. The results of this exercise are presented in Table 16.

Table 16. Amount (g) of each vegetable that could be consumed daily without exceeding the TDI for Pb. The amounts are for fresh vegetables and are over and above the daily intake of Pb from other sources such as food purchased from a grocery store, soil, air, and water. Consumption amounts were calculated only for those gardens which had samples with Pb concentrations above the laboratory detection limit.

Garden Site	Tolerable Daily Intake (ug/kg bw)	Vegetable	Amount (g) Required to Exceed Tolerable Daily Intake				
			Infant	Toddler	Child	Teen	Adult
TQ0164	3.57	Lettuce	18	28	91	248	313
TQ0166	3.57	Lettuce	27	44	140	382	482
TQ0165	3.57	Lettuce	36	58	185	504	635
TQ0167	3.57	Lettuce	47	75	241	657	829
TQ0168	3.57	Lettuce	26	42	135	368	465
TQ0170	3.57	Lettuce	46	75	239	651	821
TQ0169	3.57	Lettuce	30	49	157	428	540
TQ0171	3.57	Lettuce	39	63	202	551	695
TQ0172	3.57	Lettuce	79	128	409	1,115	1,407
TQ0173	3.57	Lettuce	502	981	2,543	6,169	7,716
TQ0174	3.57	Lettuce	1,156	2,738	7,528	18,424	23,110
TQ0164	3.57	Beans	239	386	1,232	3,362	4,241
TQ0166	3.57	Beans	601	973	3,105	8,473	10,690
TQ0165	3.57	Beans	575	931	2,970	8,106	10,227
TQ0167	3.57	Beans	531	859	2,742	7,483	9,441
TQ0168	3.57	Beans	694	1,122	3,581	9,773	12,331
TQ0170	3.57	Beans	644	1,041	3,324	9,071	11,445
TQ0169	3.57	Beans	593	959	3,061	8,354	10,540
TQ0171	3.57	Beans	825	1,334	4,256	11,616	14,656
TQ0172	3.57	Beans	911	1,473	4,702	12,833	16,191
TQ0174	3.57	Beans	110	260	714	1,748	2,192
TQ0164	3.57	Carrots	128	208	663	1,810	2,283
TQ0166	3.57	Carrots	562	909	2,901	7,917	9,989
TQ0165	3.57	Carrots	223	360	1,150	3,139	3,961
TQ0167	3.57	Carrots	332	537	1,715	4,680	5,905
TQ0168	3.57	Carrots	396	640	2,042	5,572	7,030
TQ0170	3.57	Carrots	1,182	1,912	6,102	16,652	21,010
TQ0169	3.57	Carrots	570	921	2,941	8,025	10,125
TQ0171	3.57	Carrots	908	1,469	4,687	12,790	16,138
TQ0172	3.57	Carrots	4,228	6,839	21,825	59,561	75,148
TQ0173	3.57	Carrots	2,593	5,072	13,148	31,896	39,897
TQ0164	3.57	Potatoes	259	419	1,336	3,647	4,601
TQ0165	3.57	Potatoes	382	617	1,969	5,374	6,781

Since the highest concentrations of Pb occurred in lettuce, the amount of lettuce that could be consumed from each garden without exceeding the TDI for Pb was low relative to the amounts calculated for the other vegetables. For example, based on data from site TQ0164, a toddler weighing 13 kg could eat up to approximately 208 g of carrots or 419 g of potatoes and not exceed the TDI for Pb (see Figure 21). However, the same toddler could only consume about 28 g of lettuce before exceeding the TDI. While this seems like a small amount relative to the amounts calculated for carrots and beans, it is still above the total estimated intake of garden vegetables for a toddler (see Table 10). Furthermore, assuming that the entire vegetable intake from Flin Flon gardens was lettuce, then, based on the estimated intakes in Table 10, the amount of Pb ingested would be less than 10% of the TDI for the metal for all age/weight classes. Thus, exposure to Pb through eating locally grown lettuce or any of the other vegetables used in this study is not considered a health concern to the consumer.

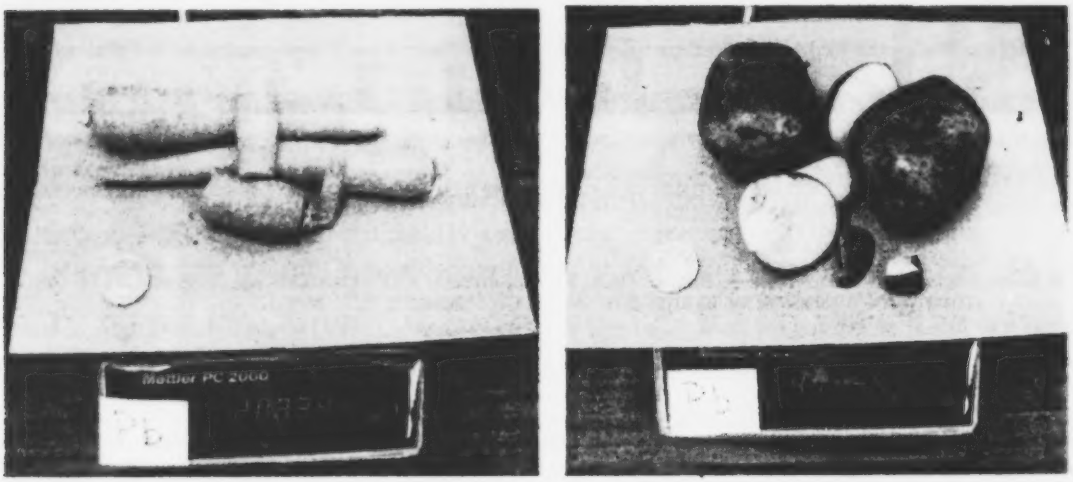

Figure 21. Approximate amount of fresh carrots or potatoes a 13 kg toddler could consume daily from site TQ0164 without exceeding the TDI for Pb.

Mercury (Hg)

Total Hg levels in vegetables varied considerably between species and garden sites (Figure 22, Table 17). Lettuce grown at gardens close to the smelter complex in Flin Flon tended to accumulate higher amounts of Hg than lettuce grown at sites farther away in the community and at sites in Cranberry Portage and The Pas. Levels of Hg in carrots were above detection at all sites except the gardens in Cranberry Portage and The Pas. Concentrations in carrots were always significantly lower than concentrations in lettuce at each site. Mercury was only detected in tomato samples (unwashed) from site TQ0164 and in bean and potato samples from sitesTQ0164, TQ0165, and TQ0166.

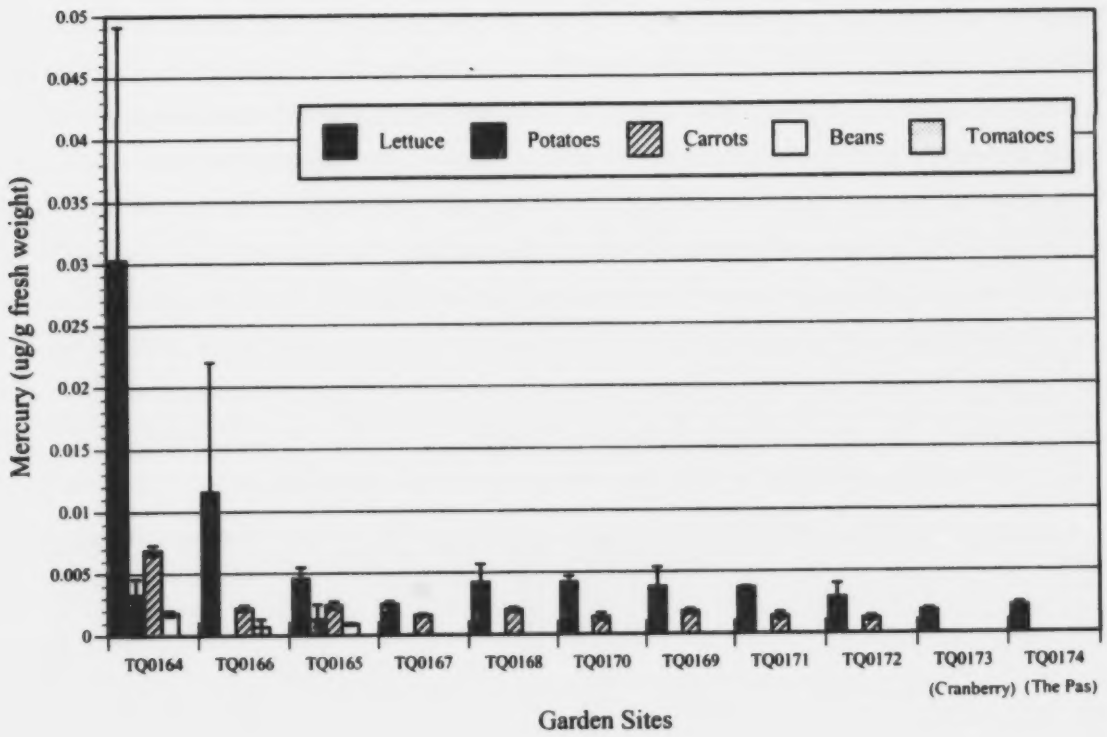

Figure 22. Mercury concentration (µg/g fresh weight) in vegetable crops grown at each garden site. All crops were washed prior to analysis. Values are means ± SD. n = 3.

Table 17. Mercury concentrations (µg/g fresh weight) in unwashed and washed vegetable samples collected from the 11 study sites. Values are means (n = 3) except in cases where only one sample was available (see text). A p-value <0.05 indicates a significant difference (*t*-test) between mean concentrations of Hg in unwashed and washed samples of the same vegetable. (n/s = no sample available).

Garden	Carrots	Potatoes	Beans			Tomatoes			Lettuce		
Site	washed	washed	unwashed	washed	p-value	unwashed	washed	p-value	unwashed	washed	p-value
TQ0164	0.007	0.003	0.004	0.002	**0.0034**	0.007	<		0.137	0.030	**0.0009**
TQ0166	0.002	<	0.001	0.001	0.1161	<	<		0.009	0.012	0.7534
TQ0165	0.002	0.001	0.001	0.001	0.8444	<	<		0.011	0.005	**0.0140**
TQ0167	0.002	<	<	<		<	<		0.008	0.003	**0.0232**
TQ0168	0.002	<	n/s	<		<	<		0.007	0.004	0.1012
TQ0170	0.001	<	<	<		<	<		0.008	0.004	**0.0058**
TQ0169	0.002	<	n/s	<		n/s	<		0.011	0.004	**0.0053**
TQ0171	0.001	<	<	<		<	<		n/s	0.004	
TQ0172	0.001	<	n/s	<		n/s	<		0.010	0.003	0.1008
TQ0173	<	<	<	<		<	<		0.001	0.002	0.0671
TQ0174	<	<	<	<		<	<		0.002	0.002	

Mercury levels were significantly lower in washed lettuce than in unwashed lettuce from most sites sampled. This indicates that Hg was being deposited on the surface of the leaves. However, it is not known whether the source of this atmospheric deposition was smelter emissions, dust from the tailings impoundment, dirt splash from the soil, or a combination of all three. The presence of Hg in washed samples indicates that Hg was absorbed into the plants. Hutchinson and Meema (1987, as referenced in Dudka and Miller 1999) stated that Hg is generally more readily absorbed through atmospheric portions of plants rather than through roots, and therefore the amount of Hg in plants does not necessarily directly reflect the Hg content of the soil. This suggests that at least a portion of the Hg present in the washed lettuce samples in Flin Flon gardens entered the plants through the leaves. Statistical analysis of the Hg data, however, revealed a strong positive correlation between concentrations of Hg in washed lettuce samples and concentrations in the soil ($r = 0.886$), which implies that the concentration of Hg in lettuce may also be related to the concentration of Hg in the soil.

The JECFA recommends a TWI for methyl mercury of 1.6 µg/kg/bw (FAO/WHO 2004). This equates to a TDI of approximately 0.23 µg/kg/bw. Thus, the TDI for methyl mercury from all sources for a 70 kg adult is approximately 50 µg, while that of a 13 kg toddler is approximately 9.2 µg. The mean Hg concentration in each vegetable from each site was used to estimate the maximum amount of each vegetable species (fresh weight) that could be eaten without exceeding the TDI for methyl mercury for a variety of age/weight classes (Table 18). Estimates of dietary intake of Hg from supermarket foods were obtained from Health Canada (1996). Mercury concentration data from the garden soils and two samples of Flin Flon drinking water collected by the authors in 2000 and 2002 were used to estimate intake of Hg via soil and water ingestion. Because concentration data for Hg in Flin Flon air were not available, the intake of Hg through inhalation was estimated using figures for typical Hg exposure through inhalation of household dust (Health Canada 1996). The Hg measured in Flin Flon vegetables, soil, and water is for total Hg concentrations. However, for the purpose of this assessment, all of the mercury was assumed to be in the form of methyl mercury.

Mercury concentrations were higher in lettuce than in the other vegetables grown in the study. As a result, the amount of lettuce from each garden that could be consumed without exceeding the TDI was low relative to the other vegetables (Table 18). This said, the consumption amounts calculated using the worst case scenario data (from site TQ0164) were still higher than the estimated amount of backyard garden lettuce that is normally eaten on a daily basis. As well, it should be noted that the calculations assumed that all of the Hg present was in the form of methyl mercury, when in reality methyl mercury would likely only make up a fraction of the total Hg present. Furthermore, even if the intake of vegetables from Flin Flon gardens consisted entirely of lettuce, the amount of Hg ingested would be

between 0.4 % and 4.3 % of the TDI for adults and between 1.2 % and 12.2 % of the TDI for toddlers. As with the other metals, the high end of this range is from produce grown at site TQ0164. Based on these results the health risk associated with exposure to Hg through ingestion of locally grown garden vegetables is considered negligible.

Table 18. Amount (g) of each vegetable that could be consumed daily without exceeding the TDI for Hg. The amounts are for fresh vegetables and are over and above the daily intake of Hg from other sources such as food purchased from a grocery store, soil, air, and water. Consumption amounts were calculated only for those gardens which had samples with Hg concentrations above the laboratory detection limit.

Garden Site	Tolerable Daily Intake (ug/kg bw)	Vegetable	Amount (g) Required to Exceed Tolerable Daily Intake				
			Infant	Toddler	Child	Teen	Adult
TQ0164	0.23	Lettuce	25	19	93	302	386
TQ0166	0.23	Lettuce	99	114	376	1,072	1,357
TQ0165	0.23	Lettuce	251	287	951	2,709	3,428
TQ0167	0.23	Lettuce	455	521	1,723	4,910	6,214
TQ0168	0.23	Lettuce	272	311	1,028	2,930	3,708
TQ0170	0.23	Lettuce	271	310	1,027	2,926	3,702
TQ0169	0.23	Lettuce	307	351	1,162	3,311	4,190
TQ0171	0.23	Lettuce	313	358	1,184	3,375	4,271
TQ0172	0.23	Lettuce	402	460	1,524	4,343	5,496
TQ0173	0.23	Lettuce	679	912	2,582	6,866	8,676
TQ0174	0.23	Lettuce	575	774	2,186	5,808	7,339
TQ0164	0.23	Beans	413	316	1,550	5,045	6,452
TQ0166	0.23	Beans	1,139	870	4,270	13,898	17,772
TQ0165	0.23	Beans	845	645	3,167	10,307	13,180
TQ0164	0.23	Carrots	109	83	409	1,332	1,703
TQ0166	0.23	Carrots	335	256	1,257	4,092	5,233
TQ0165	0.23	Carrots	307	234	1,150	3,742	4,785
TQ0167	0.23	Carrots	481	367	1,802	5,866	7,502
TQ0168	0.23	Carrots	368	281	1,380	4,491	5,743
TQ0170	0.23	Carrots	552	422	2,070	6,737	8,615
TQ0169	0.23	Carrots	407	311	1,527	4,970	6,356
TQ0171	0.23	Carrots	523	400	1,963	6,388	8,169
TQ0172	0.23	Carrots	652	498	2,445	7,958	10,177
TQ0164	0.23	Potatoes	230	176	864	2,811	3,595
TQ0165	0.23	Potatoes	561	429	2,103	6,846	8,754

Selenium (Se)

Selenium was found at relatively high levels in vegetables grown at site TQ0164, but was either not detected or was only slightly above the detection limit in vegetables grown at the remaining garden sites (Figure 23, Table 19). Washing did not significantly reduce the concentration of Se in the vegetables collected at TQ0164 (Table 19). This suggests that much of the Se in the vegetables was taken in from the soil rather than from deposition and absorption through aerial parts of the plant. The availability of

Se for uptake by plants is influenced by a number of factors (CCME 1999). The concentration of the element in the soil is certainly important, and the Se content of vegetables from TQ0164 is reflective of the high concentration of Se in the soil at the site (which was more than twice that of the other gardens in Flin Flon). Site TQ0164 was the oldest garden in the study, and as such has been exposed to smelter emissions for a significantly longer period of time than the other gardens. Selenium is taken up by plants as selenites and selenates, but the latter form tends to be more readily available for uptake by plants because they adhere less strongly to soil particles and organic matter (CCME 1999). Thus, the proportion of Se that is present as selenites or selenates can also influence the amount of Se that is available for uptake and accumulation by plants. Availability of Se for uptake by plants is also strongly influenced by soil pH, organic matter, clay content, and phosphate and sulphate concentrations (CCME 1999). As such, the Se concentrations in vegetables from TQ0164 were likely the result of a combination of factors including soil characteristics and chemistry and the concentration and form of Se in the soil.

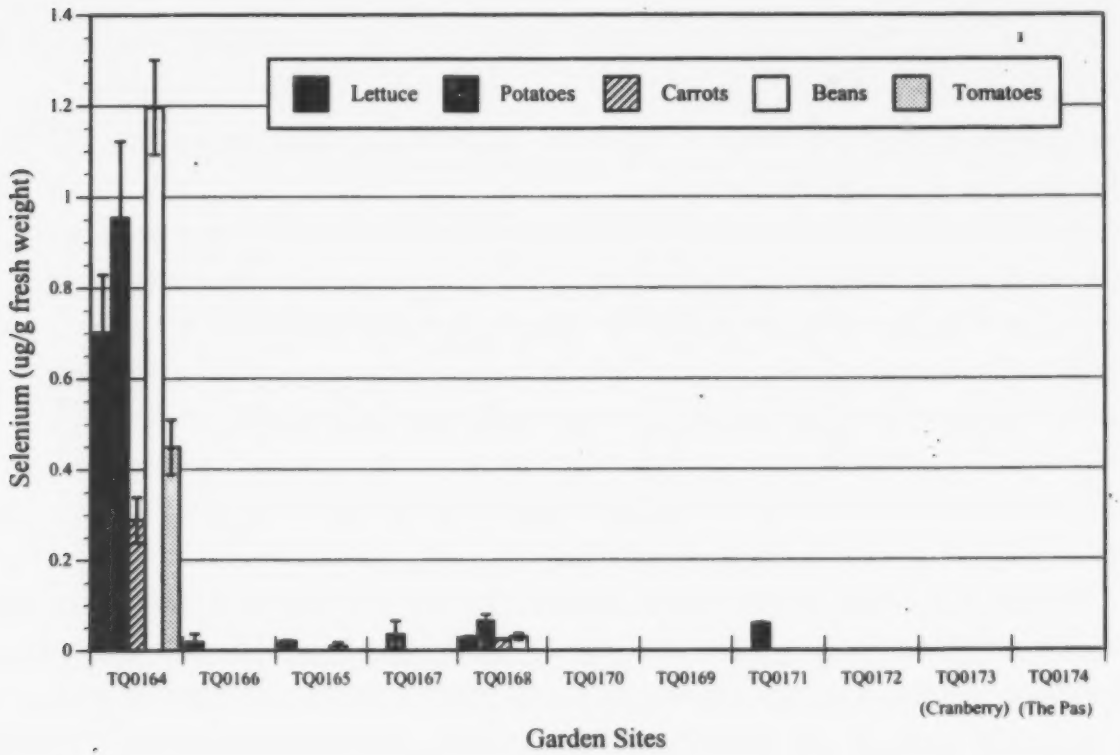

Figure 23. Selenium concentration (µg/g fresh weight) in vegetable crops grown at each garden site. All crops were washed prior to analysis. Values are means ± SD. n = 3.

Table 19. Selenium concentrations (µg/g fresh weight) in unwashed and washed vegetable samples collected from the 11 study sites. Values are means (n = 3) except in cases where only one sample was available (see text). A p-value <0.05 indicates a significant difference (*t*-test) between mean concentrations of Se in unwashed and washed samples of the same vegetable. (n/s = no sample available).

Garden	Carrots	Potatoes	Beans			Tomatoes			Lettuce		
Site	washed	washed	unwashed	washed	p-value	unwashed	washed	p-value	unwashed	washed	p-value
TQ0164	0.29	0.95	1.23	1.20	0.6347	0.51	0.45	0.2095	0.83	0.70	0.1747
TQ0166	<	<	<	<		<	<		0.03	0.02	0.4818
TQ0165	<	<	<	<		<	<		0.03	0.02	0.0814
TQ0167	<	0.03	<	<		<	<		0.02	<	
TQ0168	0.02	0.07	n/s	0.03		<	<		0.04	0.03	**0.0101**
TQ0170	<	<	<	<		<	<		0.02	<	
TQ0169	<	<	n/s	<		n/s	<		0.03	<	
TQ0171	<	0.06	<	<		<	<		n/s	<	
TQ0172	<	<	n/s	<		n/s	<		<	<	
TQ0173	<	<	<	<		<	<		<	<	
TQ0174	<	<	<	<		<	<		<	<	

The JECFA has not developed a tolerable intake amount for Se. The TWI of 35 µg/kg/bw used in this report is based upon information in ATSDR (2001). This weekly tolerable intake is equal to a TDI of 5 µg/kg/bw or 350 µg for a 70 kg adult.

The Se concentration data was used to estimate the amount of each vegetable (fresh weight) from each site that could be eaten without exceeding the TDI of 5 µg/kg/bw. Human intake values for Se were derived from two different sources in the literature. However, because neither of these sources differentiated between dietary and non-dietary intake of the element, it was not possible to incorporate any Flin Flon specific data into the total intake amount. Intake values for adults and toddlers were obtained from information referenced in CCME (1999). Intake by teens was assumed to be the same as adults, while intake by children was obtained from information in UK Environment Agency (2002). Information regarding intake by infants was not available.

Beans grown at garden site TQ0164 had the highest fresh weight concentrations of Se, followed by potatoes, lettuce, tomatoes, and carrots. Consequently, the amount of vegetable material from site TQ0164 that could be eaten without exceeding the TDI was relatively low for beans and increased sequentially for potatoes, lettuce, tomatoes, and carrots (Table 20). For example, a toddler weighing 13 kg could consume up to approximately 25 g of beans, 31 g of potatoes, 43 g of lettuce, 67 g of tomatoes, or 103 g of carrots from site TQ0164 before exceeding the TDI for Se. All these amounts, with the exception of potatoes, were well below the usual daily intake for these particular vegetables (Table 9). The usual daily intake for potatoes by a toddler is estimated at 45.22 g, which may present some cause

for concern since a toddler consuming this amount would exceed the TDI for Se. One has to keep in mind, however, that this relates to a 13 kg toddler eating potatoes specifically from site TQ0164. The data shows that the relatively high concentrations of Se in the vegetables of TQ0164 was likely anomalous and the amount of Se in the vegetables at the other sites was either below or just slightly above detection. This, along with the fact that vegetables from private gardens usually only make up a relatively small portion of the overall diet and are generally not eaten on a daily basis throughout the year, indicates that Se concentrations in vegetables grown in Flin Flon does not present a risk to the consumer.

Table 20. Amount (g) of each vegetable that could be consumed daily without exceeding the TDI for Se. The amounts are for fresh vegetables and are over and above the daily intake of Se from other sources such as food purchased from a grocery store, soil, air, and water. Consumption amounts were calculated only for those gardens which had samples with Se concentrations above the laboratory detection limit.

Garden Site	Tolerable Daily Intake (ug/kg bw)	Vegetable	Consumption Amount (g) Required to Exceed Tolerable Daily Intake			
			Toddler	Child	Teen	Adult
TQ0164	5	Lettuce	43	138	333	409
TQ0166	5	Lettuce	1,660	5,395	12,971	15,930
TQ0165	5	Lettuce	1,530	4,975	11,962	14,690
TQ0168	5	Lettuce	1,041	3,384	8,137	9,993
TQ0164	5	Bean	25	81	195	240
TQ0165	5	Bean	3,252	10,573	25,421	31,218
TQ0168	5	Bean	1,004	3,264	7,848	9,637
TQ0164	5	Tomato	67	216	520	639
TQ0164	5	Carrot	103	336	809	993
TQ0168	5	Carrot	1,220	3,966	9,535	11,710
TQ0164	5	Potato	31	102	245	301
TQ0167	5	Potato	855	2,781	6,686	8,210
TQ0168	5	Potato	459	1,493	3,590	4,409
TQ0171	5	Potato	504	1,639	3,940	4,839

Zinc (Zn)

Zinc concentrations in vegetables collected at the study sites followed a pattern similar to concentrations of Cu. Zinc was detected in varying amounts in all of the vegetable samples (Figure 24, Table 21), with the highest concentrations occurring in lettuce samples and the lowest in tomato samples. Lettuce samples collected in Flin Flon had mean concentrations ranging between 4.7 µg/g at garden TQ0172 and 28.6 µg/g at site TQ0164. Mean concentrations of Zn in lettuce from the gardens in Cranberry Portage and The Pas were 2.9 µg/g and 4.1 µg/g, respectively. Statistical analysis indicated

that the Zn concentrations in lettuce from the Cranberry Portage and The Pas sites did not vary significantly from each other, but both were significantly lower than the concentrations of Zn in lettuce from gardens in Flin Flon.

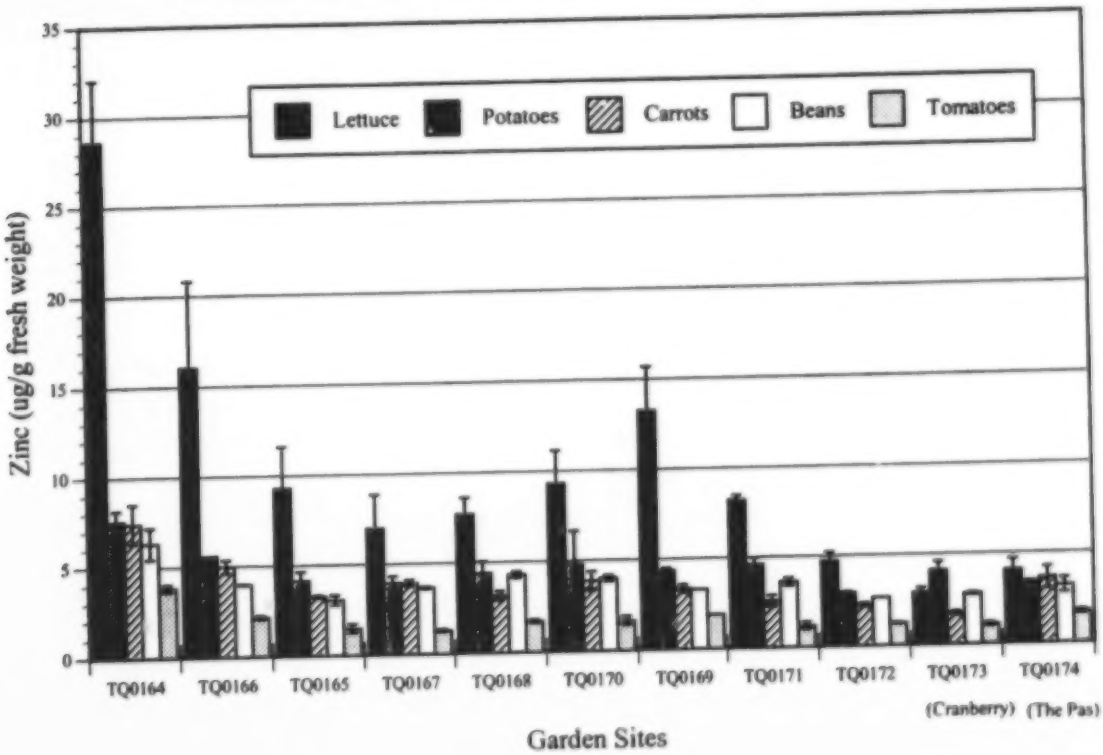

Figure 24. Zinc concentration (μg/g fresh weight) in vegetable crops grown at each garden site. All crops were washed prior to analysis. Values are means ± SD. n = 3.

The Zn content of potatoes, beans, and carrots were very similar at all of the sites sampled in Flin Flon. This was also true for the gardens in The Pas and Cranberry Portage. However, unlike the situation in Flin Flon where the concentrations of Zn were always significantly higher in lettuce than in the other vegetables, the concentrations of Zn in lettuce from gardens in The Pas and Cranberry Portage were comparable to levels of Zn in the other vegetables.

Washed lettuce samples collected at the Flin Flon sites had lower mean concentrations of Zn than unwashed samples, and most of these differences were statistically significant or very close to being statistically significant. Levels of Zn in washed and unwashed lettuce samples from the sites in Cranberry Portage and The Pas, however, were not significantly different. These results imply that Zn

was deposited onto the leaf surface of the lettuce grown in Flin Flon but not onto the leaves of the lettuce grown in The Pas and Cranberry Portage. Levels of Zn in washed bean and tomato samples from Flin Flon were not significantly lower than levels in unwashed samples. This indicates that Zn did not accumulate on the surface of beans and tomatoes and suggests that Zn intake by these vegetables was likely predominantly via the roots.

Table 21. Zinc concentrations (µg/g fresh weight) in unwashed and washed vegetable samples collected from the 11 study sites. Values are means (n = 3) except in cases where only one sample was available (see text). A p-value <0.05 indicates a significant difference (*t*-test) between mean concentrations of Zn in unwashed and washed samples of the same vegetable. (n/s = no sample available).

Garden	Carrots	Potatoes	Beans			Tomatoes			Lettuce		
Site	washed	washed	unwashed	washed	p-value	unwashed	washed	p-value	unwashed	washed	p-value
TQ0164	7.4	7.6	6.5	6.3	0.7341	4.0	3.8	0.2947	63.9	28.6	**0.0003**
TQ0166	5.0	5.6	4.0	4.0	0.6704	2.4	2.2	0.2944	16.8	16.1	0.9146
TQ0165	3.2	4.2	3.2	3.1	0.5711	1.4	1.5	0.8394	16.7	9.3	0.0573
TQ0167	3.9	4.0	3.7	3.7	0.3948	1.4	1.3	0.5110	12.3	7.0	0.0575
TQ0168	3.1	4.4	n/s	4.3		1.7	1.7	0.8004	12.3	7.7	**0.0018**
TQ0170	3.9	4.8	4.2	4.0	0.5127	1.7	1.6	0.5767	16.1	9.3	**0.0128**
TQ0169	3.3	4.4	n/s	3.3		n/s	1.9		21.4	13.3	**0.0317**
TQ0171	2.6	4.6	3.5	3.6	0.5737	1.2	1.2	0.7089	n/s	8.2	
TQ0172	2.2	2.9	n/s	2.7		n/s	1.2		7.4	4.7	**0.0119**
TQ0173	1.7	4.1	2.8	2.8	0.8410	1.2	1.1	0.7499	2.8	2.9	0.8553
TQ0174	3.6	3.4	3.2	3.2	0.9444	1.6	1.7	0.4672	4.8	4.1	0.1344

The JECFA recommends a TDI for Zn from all sources of 1 mg/kg/bw (FAO/WHO 2001). This is equivalent to a TDI of 70 mg of Zn for a 70 kg adult. The TDI for Zn is high relative to the TDI of most other metals. This is because Zn is an essential nutrient required for enzymatic activity by both plants and animals (Starr and Taggart 1987) and is only toxic to humans and other animal life at very high levels (CCME 1999, WHO 2001). The Institute of Medicine (2002) suggests a dietary reference intake for Zn of approximately 8 mg/day for women and 11 mg/day for men. The Zn concentration data collected in this study were used to calculate the amount of each vegetable from each garden that could be consumed without exceeding the TDI for Zn under a variety of age/weight classes. The total daily human intake of Zn from all sources was based on dietary consumption rates in the United States (median values of the ranges provided) (WHO 2001) plus values obtained from soil, air, and water data specific to Flin Flon. The total daily intake value was then subtracted from the TDI and the result was used to calculate the maximum amount of each vegetable from each site that could be consumed without exceeding the TDI for Zn (Table 22).

Table 22. Amount (g) of each vegetable that could be consumed daily without exceeding the TDI for Zn. The amounts are for fresh vegetables and are over and above the daily intake of Zn from other sources such as food purchased from a grocery store, soil, air, and water.

Garden Site	Tolerable Daily Intake (ug/kg bw)	Vegetable	Consumption Amount (g) Required to Exceed Tolerable Daily Intake				
			Infant	Toddler	Child	Teen	Adult
TQ0164	1000	Lettuce	31	133	621	1,541	2,066
TQ0166	1000	Lettuce	55	237	1,108	2,750	3,686
TQ0165	1000	Lettuce	95	408	1,909	4,739	6,352
TQ0167	1000	Lettuce	126	542	2,537	6,298	8,442
TQ0168	1000	Lettuce	115	494	2,313	5,742	7,696
TQ0170	1000	Lettuce	95	408	1,909	4,739	6,352
TQ0169	1000	Lettuce	66	287	1,341	3,330	4,463
TQ0171	1000	Lettuce	107	463	2,168	5,381	7,213
TQ0172	1000	Lettuce	186	802	3,751	9,313	12,484
TQ0173	1000	Lettuce	345	1,385	6,248	15,404	20,632
TQ0174	1000	Lettuce	244	979	4,412	10,875	14,566
TQ0164	1000	Beans	140	602	2,818	6,996	9,377
TQ0166	1000	Beans	222	956	4,474	11,107	14,888
TQ0165	1000	Beans	288	1,241	5,804	14,409	19,313
TQ0167	1000	Beans	241	1,040	4,867	12,082	16,194
TQ0168	1000	Beans	205	885	4,139	10,277	13,775
TQ0170	1000	Beans	220	951	4,448	11,043	14,802
TQ0169	1000	Beans	268	1,155	5,403	13,415	17,981
TQ0171	1000	Beans	244	1,051	4,916	12,205	16,359
TQ0172	1000	Beans	332	1,432	6,697	16,627	22,287
TQ0173	1000	Beans	357	1,432	6,464	15,937	21,346
TQ0174	1000	Beans	312	1,251	5,637	13,893	18,608
TQ0164	1000	Tomatoes	230	991	4,637	11,513	15,432
TQ0166	1000	Tomatoes	410	1,766	8,264	20,516	27,498
TQ0165	1000	Tomatoes	599	2,582	12,081	29,992	40,201
TQ0167	1000	Tomatoes	691	2,979	13,936	34,599	46,376
TQ0168	1000	Tomatoes	518	2,234	10,451	25,946	34,777
TQ0170	1000	Tomatoes	540	2,330	10,901	27,064	36,276
TQ0169	1000	Tomatoes	469	2,023	9,464	23,495	31,492
TQ0171	1000	Tomatoes	759	3,275	15,321	38,036	50,983
TQ0172	1000	Tomatoes	716	3,086	14,437	35,842	48,041
TQ0173	1000	Tomatoes	921	3,694	16,668	41,095	55,042
TQ0174	1000	Tomatoes	583	2,336	10,528	25,948	34,754
TQ0164	1000	Carrots	119	513	2,399	5,955	7,982
TQ0166	1000	Carrots	176	761	3,561	8,841	11,850
TQ0165	1000	Carrots	271	1,170	5,473	13,587	18,211
TQ0167	1000	Carrots	225	972	4,548	11,291	15,134
TQ0168	1000	Carrots	281	1,211	5,664	14,062	18,849
TQ0170	1000	Carrots	228	985	4,610	11,444	15,340
TQ0169	1000	Carrots	264	1,138	5,322	13,213	17,710
TQ0171	1000	Carrots	344	1,484	6,941	17,232	23,098
TQ0172	1000	Carrots	393	1,695	7,927	19,681	26,380
TQ0173	1000	Carrots	585	2,348	10,596	26,124	34,990
TQ0174	1000	Carrots	275	1,104	4,975	12,260	16,421
TQ0164	1000	Potatoes	116	502	2,349	5,832	7,817
TQ0166	1000	Potatoes	158	681	3,188	7,914	10,608
TQ0165	1000	Potatoes	212	915	4,280	10,626	14,243
TQ0167	1000	Potatoes	222	960	4,489	11,145	14,938
TQ0168	1000	Potatoes	200	861	4,030	10,004	13,409
TQ0170	1000	Potatoes	183	790	3,695	9,174	12,296
TQ0169	1000	Potatoes	202	872	4,081	10,133	13,582
TQ0171	1000	Potatoes	191	824	3,857	9,575	12,834
TQ0172	1000	Potatoes	300	1,295	6,056	15,035	20,152
TQ0173	1000	Potatoes	242	971	4,382	10,804	14,471
TQ0174	1000	Potatoes	293	1,175	5,294	13,047	17,475

The amount of each vegetable that could be eaten without exceeding the TDI for Zn varied considerably between sites and between vegetables (Table 22). Although lettuce was the greatest accumulator of Zn at the garden sites in Flin Flon, because the TDI is relatively high, the amount of lettuce that could be consumed was also high for all gardens, including site TQ0164. For example, a 13 kg toddler eating lettuce from site TQ0164 could consume at least 133 g of the lettuce before exceeding the TDI, while a 70 kg adult under the same circumstances could eat over 2 kg of lettuce. Consumption amounts calculated for the other vegetables are considerably higher, with the same toddler having to consume over 500 g of potatoes or carrots, over 600 g of beans, or almost 1 kg of tomatoes in order to exceed the TDI. Given that these amounts are a great deal higher than the usual daily intake of these vegetables for all age groups, the health risk from exposure to Zn in lettuce and the other vegetables grown in Flin Flon gardens is considered to be negligible.

Other Metals and Elements

Concentrations of the remaining metals and other elements analyzed varied considerably between sites and between vegetable crops. Concentrations of Sb, Be, Co, tellurium (Te), Tl, Sn, V, uranium (U), and Zr were less than detection in all 31 potato samples. Chromium and Ag were detected in potato samples from only a limited number of sites and at concentrations that were only slightly above their respective detection limit. Concentrations of Sb, Be, Co, Ag, Te, Tl, Sn, U, and Zr were below detection in all 33 carrot samples. Chromium was detected in small amounts in a total of six carrot samples from sites TQ0168, TQ0171, and TQ0172, while V was detected in a single carrot sample from site TQ0172. Concentrations of Sb, Co, Ag, Te, Tl, U, V, and Zr were less than detection in all bean samples regardless of whether they had been washed or left unwashed. Beryllium was detected at low concentrations in a washed bean sample from site TQ0168, an unwashed sample from TQ0170, and a washed and unwashed sample from TQ0174. Chromium was found at levels slightly above the detection limit in 12 bean samples (eight washed and four unwashed) collected from five separate sites.

Zirconium and Te were below detectable limits in all lettuce samples. Tin was slightly above the detection limit in only two samples – an unwashed sample collected from TQ0164 and a washed sample from site TQ0165, while Sb was found in three unwashed lettuce samples from site TQ0164 and a single unwashed sample from site TQ0167. Lettuce was the only crop to have detectable levels of Sb. As well. lettuce was the only crop to have detectable levels of Tl. Thallium was found in a total of six unwashed samples from sites TQ0164, TQ0165, and TQ0168 and in single washed samples from TQ0166 and TQ0168. Levels of Tl in the three unwashed lettuce samples from TQ0164 were higher than levels in

samples from other sites. Beryllium, which was mainly absent from all other crops (except for four bean samples) was present in low concentrations in 20 of the 63 lettuce samples.

Antimony, Be, Ag, Te, Sn, Tl, U and Zr concentrations were all below their respective detection limits in all tomato samples. Vanadium was above detection in a single unwashed sample from Flin Flon site TQ0171, while Co was detected in three samples (2 unwashed and one washed) from the same site.

Comparison with Past Studies

Summary statistics were used to compare the vegetable analysis results from the studies by Pip (1991) and HBM&S (1994) and the present study (hereafter referred to in this section as the Conservation study). As with the soil samples, analysis of the vegetable samples in the Pip study was limited to Cd, Cu, and Pb, while samples collected during the HBM&S study were analyzed for Cd, Cu, Pb, As, Hg, and Zn. Twelve gardens were included in the Pip study. The majority of these were located in Flin Flon. According to Pip (1991) an attempt was made to collect and analyze three replicate samples of each vegetable from each garden site. Thus, the range and mean data available from the Pip study are from a total of 36 samples collected from 12 garden sites. The HBM&S study included seven gardens in Flin Flon from which a single sample of each vegetable was collected and analyzed. Results from an eighth garden located in Creighton were not included in calculating the summary statistics. The range and mean concentration data from the Conservation study were calculated using data from washed vegetable samples collected from the nine gardens located in Flin Flon. This included 25 potato samples, 25 tomato samples, 23 bean samples, and 27 carrot samples. Wet weight concentrations were not available in Pip and HBM&S studies, therefore dry weight concentrations rather than wet weight concentrations from the Conservation study were used to make the comparisons.

Lettuce

According to the information available, lettuce was only collected from a single site in the Pip study and from only two sites in the HBM&S study. The concentrations of metals in these lettuce samples did fall within the range of results for lettuce samples from the Conservation study. However, because the sample sizes in the Pip and HBM&S studies are limited, any truly meaningful comparison between lettuce results from the three studies was not possible

Potatoes and Beans

Potatoes and beans were collected and analyzed in the Pip and Conservation studies, but not in the HBM&S study. Cadmium concentrations in potato and bean samples were an order of magnitude higher in the Pip study than in the study conducted by Conservation (Figures 25 and 26, respectively). The

majority of the potato samples from the Conservation study had Pb concentrations below detection (<0.1 µg/g). Concentrations in the six potato samples in which Pb was detected were much lower than those reported in the Pip study (Figure 25). Levels of Pb in bean samples were also considerably lower in the Conservation study than in the Pip study (Figure 26). Concentrations of Cu in potato and bean samples were, however, fairly similar between the two studies (Figures 25 and 26, respectively).

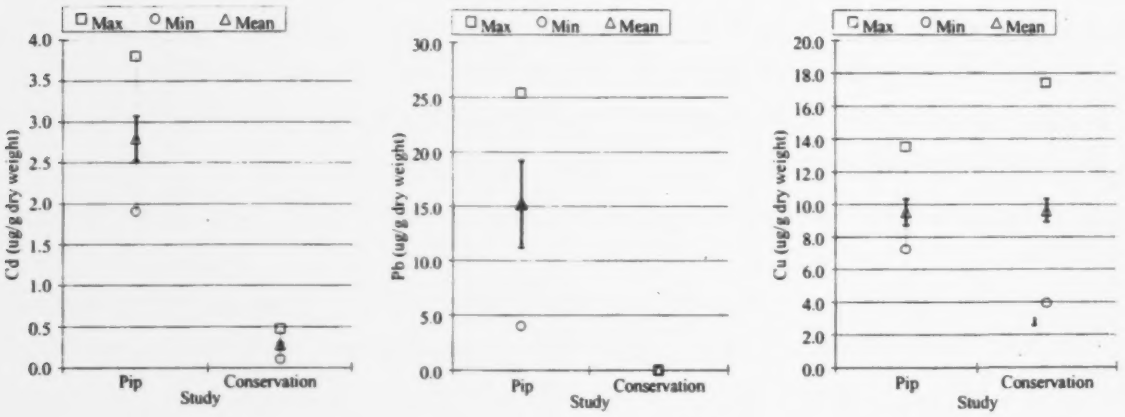

Figure 25. Mean (± SE) and range in metal concentrations (µg/g dry weight) in potato samples collected during the study by Pip and the present study by Conservation.

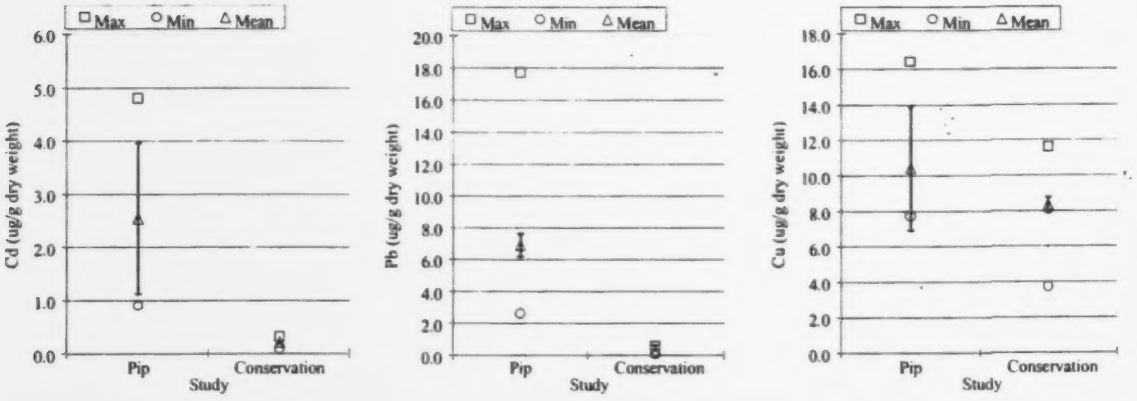

Figure 26. Mean (± SE) and range in metal concentrations (µg/g dry weight) in bean samples collected during the study by Pip and the present study by Conservation.

Carrots

Carrot samples were collected and analyzed in all three studies. Cadmium and Pb concentrations in carrots collected in the Pip study were considerably higher than concentrations in the Conservation study (Figure 27). Cadmium and Pb concentrations in carrots were also lower in the HBM&S study than in the Pip study. However, because the majority of the HBM&S concentrations were less than detection and the detection limits were relatively high, it was not possible to determine precisely how similar or dissimilar they were from the Pip and Conservation studies. Copper concentrations in carrots were comparable between studies (Figure 27). Mean and minimum concentrations were similar, while concentrations in the HBM&S study ranged somewhat higher than concentrations in the Pip and Conservation studies. Carrots were not analyzed for As, Hg, and Zn in the Pip study. Concentrations of As and Zn in the HBM&S and Conservation studies were fairly similar, while concentrations of Hg were decidedly higher in the HBM&S study than in the Conservation study (Figure 27).

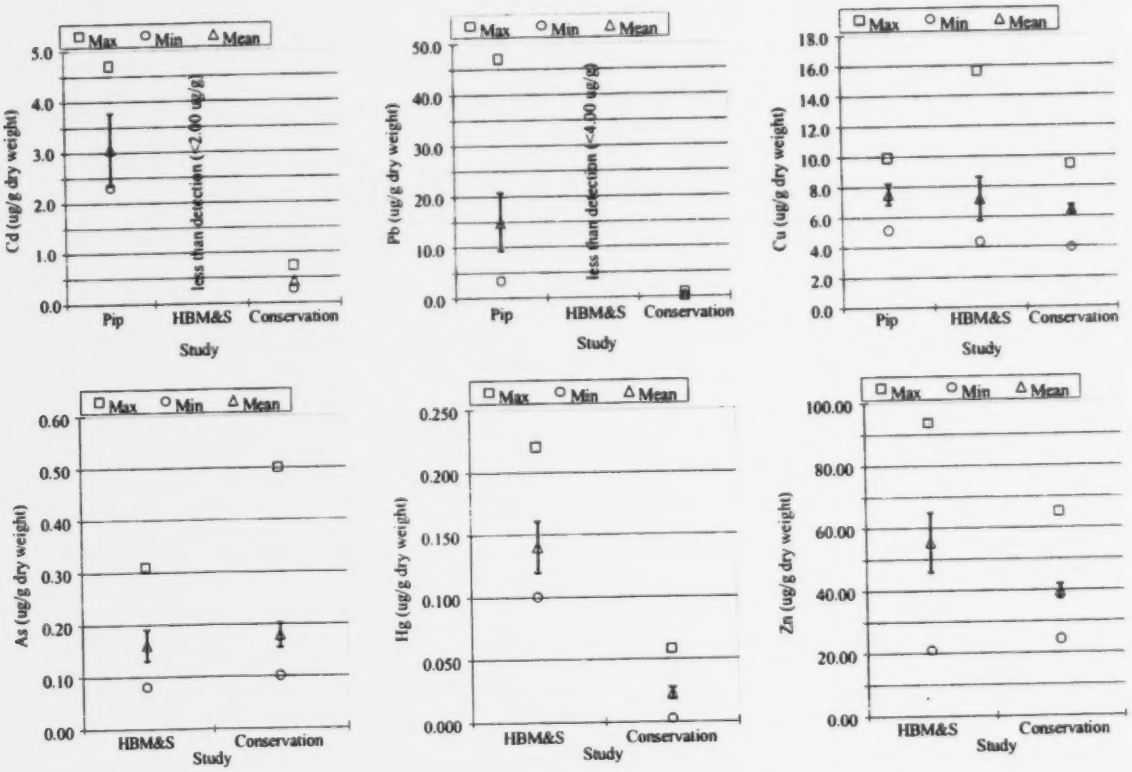

Figure 27. Mean (± SE) and range in metal concentrations (µg/g dry weight) in carrot samples collected during the studies by Pip and HBM&S and the present study by Conservation.

Tomatoes

Cadmium concentrations in tomatoes collected in the Pip study were considerably higher than concentrations in the Conservation study (Figure 28). Concentrations in five of the seven tomato samples collected in the HBM&S study were less than detection (<2.00 µg/g). This suggests that Cd concentrations in tomatoes were generally lower in the HBM&S study than in the Pip study. However, because of the relatively high minimum detection limit, it is not possible to tell the degree to which the two studies differed. It is possible that the actual concentrations in the HBM&S were more comparable to the results from the Conservation study. Lead concentrations in tomatoes in the Pip study were considerably higher than those reported in the other studies. Lead was above detection in only one sample in the HBM&S study (detection limit of 4.00 µg/g) and only two samples in the Conservation study (detection limit of 0.1 µg/g). As with the other vegetables, mean concentrations of Cu in tomatoes were comparable between all three studies (Figure 28). Arsenic and Hg were detected at low levels in all samples collected in the HBM&S study. Mercury concentrations in the Conservation study were less than detection (<0.01 µg/g) in all but one tomato sample, and As was above the detection limit (0.1 µg/g) in only two tomato samples. Thus, although it appears that the Hg and As concentrations in tomatoes from the HBM&S study were generally higher than those of the Conservation study, this may not be correct since the detection limits between the studies were different. As with Cu, although the range in concentrations was somewhat variable, the mean concentrations of Zn in tomato samples were reasonably similar between the HBM&S and Conservation studies (Figure 28).

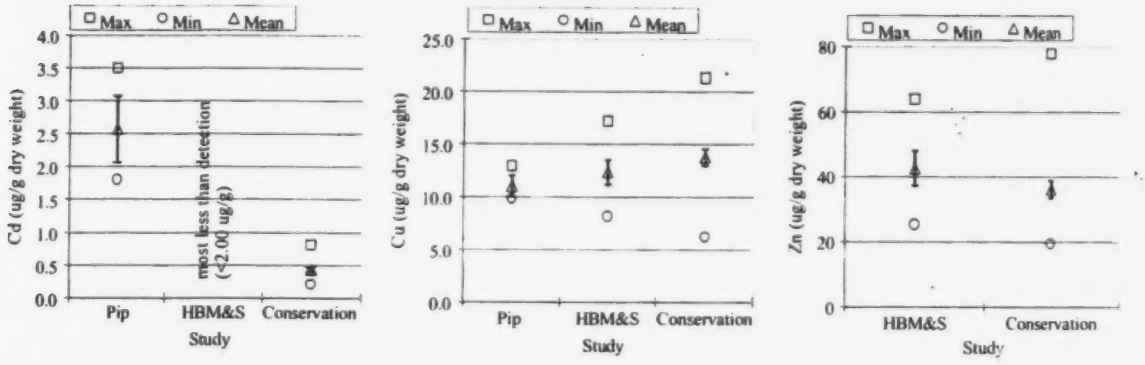

Figure 28. Mean (± SE) and range in metal concentrations (µg/g dry weight) in tomato samples collected during the studies by Pip and HBM&S and the present study by Conservation.

Summary

The location and number of garden sites, the sample sizes, the laboratory detection limits, and the specific vegetable cultivars differed between all three studies. As well, unlike the Conservation study, there was little consistency in the vegetable crops or specific cultivars sampled within the Pip and HBM&S studies. Thus, it was not surprising that the results were variable and sometimes quite dissimilar between the studies. This said, the large difference in Pb and Cd concentrations observed between the Pip study and the HBM&S and Conservation studies was not expected. Particularly since the metal results from the HBM&S and Conservation studies and the Cu results from all three studies were generally much more similar. The high standard errors relative to the range in the data in the Pip results indicate that there was often a greater degree of variation in the Pip data than in the results from the other studies. This may be because the Pip sites were more widely distributed than the sites in the HBM&S and Conservation study, or may be indicative of differences in sampling or analytical methodology between studies. These and other differences mentioned previously make detailed comparisons of the vegetable results between the studies difficult.

SUMMARY AND CONCLUSIONS

This study was designed to determine the concentrations of metals and other elements in garden soils and vegetable crops grown in the city of Flin Flon, Manitoba, and provide an assessment of the risk associated with consuming such vegetables. Nine gardens in Flin Flon, a garden in Cranberry Portage, and a garden in The Pas were included in the study. Lettuce, beans, carrots, potatoes, and tomatoes were planted in each garden in June 2002. The same vegetable cultivars were planted in each garden. Thirty-three soil samples and 238 vegetable samples were collected from the gardens during August 2002. Samples were analyzed to determine the concentrations of total metals and other elements. The moisture content of vegetation samples and the fertility and general chemical characteristics of soil samples were also determined.

Soil concentrations of As, Cd, Cu, Pb, Hg, Se, and Zn were very highly correlated with each other and were significantly elevated at most gardens in Flin Flon relative to the garden in The Pas. In some instances the concentrations of these metals in the Flin Flon gardens exceeded established soil quality guidelines for the protection of human health, while concentrations in the soil from the gardens in Cranberry Portage and The Pas did not exceed any of the guidelines. Arsenic, Cd, Cu, Pb, Hg, and Zn are known constituents in past and present atmospheric emissions from the HBM&S smelter.

Concentrations of As, Cd, Cu, Pb, Hg, Se, and Zn in vegetables varied between sites and between vegetable species. In the majority of cases, vegetables grown in Flin Flon had higher concentrations of these metals than vegetables grown in The Pas. Lettuce tended to accumulate the highest concentrations of metals, followed by carrots and potatoes, beans, and tomatoes. Concentrations in vegetable samples were often highly correlated with soil concentrations of some metals. For example, concentrations in washed lettuce, potato, and carrot samples were highly correlated ($r > 7$) with Hg and Cd concentrations in the soil, suggesting that these vegetables absorbed the metals from the soil. Comparisons between unwashed and washed samples of lettuce indicated that atmospheric deposition of As, Cu, Zn, Pb, and, to perhaps a lesser degree, Hg had occurred during the 2002 growing season. The exact source of these metals is not known, but is likely a combination of deposition from smelter emissions, road or other incidental dust in the area, dust from the tailings impoundment, and dust and particles from the surrounding soil. Mean concentrations of metals in washed bean and tomato samples were often less than the concentrations in unwashed samples, but these differences were usually not statistically significant.

Tolerable daily intake (TDI) guidelines were used to assess the health risk associated with intake of metals through ingesting vegetables grown in the gardens in this study. The TDI levels used in this report were obtained from a number of sources including the World Health Organization (WHO) and the Agency for Toxic Substances and Disease Registry (ATSDR). The concentration data collected in this study were used to calculate the amount of each vegetable from each garden that would have to be consumed in order to exceed the TDI for each metal. Consumption amounts were calculated for several age/weight classes and these amounts were over and above the usual daily metal intake from other dietary sources and from exposure to metals in soil, air, and water in Flin Flon.

In the vast majority of cases the consumption amounts required to exceed the TDI levels were found to be well above the usual daily intake of each vegetable. Tolerable daily intake guidelines are based on consumption over the long-term, while private garden vegetables, particularly lettuce, are primarily consumed only during the two to three month growing season. Furthermore, vegetables from private gardens usually make up only a small portion of the daily diet and consumption by the most vulnerable individuals (*i.e.* toddlers and children) is usually very low. Thus, it was concluded that although consumption of vegetables grown in Flin Flon during this study had the potential to add to the overall dietary intake of As, Cd, Cu, Pb, Hg, Se, and Zn, concentrations were low enough that this did not present a health concern to the consumer.

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APPENDICES

Appendix 1. Soil and Vegetation Analysis Methods

Soil Analysis

Soil moisture (%) was determined gravimetrically by measuring the weight loss of the sample after drying. Bulk density (g/cm^3) was determined by dividing the dried weight of the sample by the sample volume. Soil pH and conductivity were determined using pH and conductivity meter probes inserted into a 2:1 water:soil saturated paste. Most total metals and other elements analysis involved strong-acid (HCl and HNO_3) digestion of a screened (10 mesh) sub-sample of soil followed by inductively coupled argon plasma spectroscopy (ICAP). Analyses for As, Cd, Se, Ag, and Tl were performed using inductively coupled plasma mass spectrometry (ICP/MS) on a strong-acid digested sub-sample, while analysis for mercury (Hg) was conducted on a digested sub-sample using cold vapour atomic fluorescence spectrophotometry. Fertility analyses were performed using procedures detailed in *Manual of Soil Sampling and Methods of Analysis* (Carter, M. R. 1993. Canadian Society of Soil Science). Analyses for exchangeable metals were performed using the ammonia acetate extraction procedure outlined in *Manual of Soil Sampling and Methods of Analysis*, followed by analysis with ICAP. All soil results were reported on a dry weight basis.

Soil moisture and bulk density were determined by the authors, while general chemistry, fertility, exchangeable metals, and total metals and other elements were determined by Cantest Laboratories, Burnaby, BC.

Vegetation Analysis

The moisture content (%) of vegetation samples was determined gravimetrically by measuring the weight loss after drying the sample for 48 hours at 60°C. Dried samples were ground with a Wiley mill to pass through a 2mm sieve and thoroughly homogenized prior to analysis. A portion of each sample was digested using a nitric acid - peroxide digestion method based on EPA Method 200.3. Digested sub-samples were then analyzed for total metals and other elements using ICAP or ICP/MS as with soil samples. Mercury in the digested sub-samples was determined using cold vapour atomic fluorescence spectrophotometry. Analytical results were reported on a dry mass basis (µg/g dry material).

Conservation staff did the moisture determinations, while Cantest Laboratories conducted sample preparations and total metals and other elements analysis.

Appendix 2. Soil Data

Table A2. Analysis results (dry weight) for replicate soil samples collected from garden sites, August 2002.

Site	Rep	Moisture	Bulk Density	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Hg	Mg	Mn	Mo
		(%)	(g/cm3)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)
TQ0164	1	18.6	0.91	12600	< 10	50.4	316	< 1	62	11	16700	41	7	636	21800	474	25.9	7310	431	< 4
TQ0164	2	14.6	0.88	15200	< 10	43	301	< 1	65	10.7	15500	45	6	571	24100	286	25.8	8400	420	< 4
TQ0164	3	16.4	0.81	13400	< 10	40.4	274	< 1	61	9.8	14900	39	6	545	21000	350	23.4	7180	374	< 4
TQ0165	1	20.1	0.86	9000	< 10	11.1	239	< 1	39	5.2	9630	30	5	277	16000	186	4.17	5100	230	< 4
TQ0165	2	18.8	0.91	9280	< 10	13.5	214	< 1	39	5.6	7940	29	5	289	16300	229	7.2	4760	243	< 4
TQ0165	3	15.8	0.83	12700	< 10	14.4	291	< 1	59	6.9	13100	39	10	376	25000	224	6.91	7220	316	< 4
TQ0166	1	31.1	0.56	9040	< 10	9.4	138	< 1	33	2.8	9590	26	2	201	12000	70	5.42	4890	198	< 4
TQ0166	2	25.8	0.66	9110	< 10	9	132	< 1	33	2.9	11500	26	3	199	12500	67	6.79	5100	197	< 4
TQ0166	3	32.9	0.61	8910	< 10	9	134	< 1	33	2.8	9530	26	3	193	12000	71	6.91	4670	193	< 4
TQ0167	1	29.3	0.76	14100	< 10	13.8	266	< 1	55	5.4	12400	41	5	248	21500	141	3.55	7660	487	< 4
TQ0167	2	29.6	0.79	14600	< 10	13.4	269	< 1	58	5.2	13300	42	5	255	22900	126	2.68	7470	554	< 4
TQ0167	3	29.4	0.69	14600	< 10	12.7	277	< 1	56	5.1	14700	42	5	262	21400	126	2.86	7980	549	< 4
TQ0168	1	19.4	0.92	13900	< 10	11.5	234	< 1	63	3.2	15600	35	7	747	25400	133	2.55	10600	597	< 4
TQ0168	2	21.1	0.94	15600	< 10	16.5	348	< 1	81	2.7	23800	37	8	281	26000	77	3.3	12100	1090	< 4
TQ0168	3	22.2	0.96	17000	< 10	8.4	310	< 1	75	2.3	19300	40	6	201	26800	59	2.43	11900	741	< 4
TQ0169	1	20.0	0.71	13000	< 10	9.1	144	< 1	48	2.6	13000	30	4	173	18600	50	1.31	6680	329	< 4
TQ0169	2	20.6	0.70	12200	< 10	8.6	145	< 1	49	2.6	14200	29	4	172	17900	55	1.43	6530	344	< 4
TQ0169	3	18.1	0.61	12500	< 10	8.9	156	< 1	55	2.8	16100	30	5	170	18500	59	1.43	6580	409	< 4
TQ0170	1	14.8	1.00	16600	< 10	8	155	< 1	57	2.3	7240	42	5	167	25400	45	1.31	8460	315	< 4
TQ0170	2	15.8	0.98	17600	< 10	8.6	163	< 1	59	2.3	7570	44	5	173	26800	48	1.43	8850	330	< 4
TQ0170	3	21.6	0.98	18100	< 10	9.1	165	< 1	59	2.4	8590	44	6	177	27100	49	1.56	9720	361	< 4
TQ0171	1	20.0	0.82	17900	< 10	6.2	184	< 1	58	1.9	9610	49	5	124	27200	28	1.68	11200	279	< 4
TQ0171	2	20.8	0.95	17700	< 10	6	184	< 1	57	1.9	9390	49	4	125	26400	30	2.05	10700	272	< 4
TQ0171	3	21.0	0.93	17500	< 10	6.2	183	< 1	56	1.9	9350	51	4	126	26200	29	2.18	10600	276	< 4
TQ0172	1	22.3	0.99	13400	< 10	3.1	129	< 1	44	0.8	6420	34	3	66	19000	12	0.58	7520	229	< 4
TQ0172	2	19.2	0.97	9880	< 10	2.8	96	< 1	32	0.8	5560	26	2	64	12900	9	0.64	5490	164	< 4
TQ0172	3	24.4	0.83	16700	< 10	3	156	< 1	54	0.8	7520	45	4	58	24700	11	0.5	9620	281	< 4
TQ0173	1	15.9	0.92	9150	< 10	3	141	< 1	48	0.5	13500	28	5	30	17300	48	0.22	8820	264	< 4
TQ0173	2	9.9	1.16	7380	< 10	1.6	77	< 1	32	< 0.2	7430	20	4	16	11500	7	0.05	6140	174	< 4
TQ0173	3	14.1	1.05	7520	< 10	1.9	82	< 1	35	0.3	10200	23	4	23	12900	23	0.07	7380	208	< 4
TQ0174	1	25.6	0.65	7360	< 10	4.6	187	< 1	34	0.3	27200	10	6	14	15700	6	0.04	7920	282	< 4
TQ0174	2	28.6	0.68	8450	< 10	5.3	212	< 1	48	0.3	33300	13	6	14	17800	8	0.02	9630	255	< 4
TQ0174	3	25.4	0.79	8340	< 10	5	202	< 1	46	0.3	35300	13	6	14	17000	7	0.02	10300	243	< 4

Table A2 continued.

Site	Rep	Ni	P (as PO4)	K	Se	Ag	Na	Sr	Tl	Ti	Sn	V	Zn	Zr	pH units	Conductivity	S	NO3-NO2 as N	Available P
		(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	(ug/g)	units	(mmhos/cm)	(%)	(ug/g)	(ug/g)
TQ0164	1	8	4720	3050	6.3	1.1	376	47	0.3	351	< 5	31	3120	< 1	7.73	0.31	0.22	13	130
TQ0164	2	11	4510	3140	5.6	1	426	46	0.3	490	< 5	38	3020	< 1	7.42	0.25	0.26	19	132
TQ0164	3	12	4140	2970	5.3	0.9	392	47	0.3	397	< 5	32	2830	< 1	7.37	0.33	0.22	17	122
TQ0165	1	15	3790	2340	1.8	1.1	135	36	0.2	337	< 5	23	1250	1	7.36	0.13	0.13	14	117
TQ0165	2	11	3150	2290	2.8	0.9	119	31	0.2	361	< 5	24	1330	2	7.37	0.16	0.17	14	148
TQ0165	3	16	5580	3590	2.4	1.7	194	38	0.2	368	< 5	31	1690	3	7.32	0.25	0.19	13	139
TQ0166	1	13	2540	2280	1.9	0.3	120	49	0.1	379	< 5	24	675	5	6.84	0.3	0.16	61	134
TQ0166	2	14	2500	2190	2.1	0.3	111	45	0.1	367	< 5	24	672	5	6.8	0.18	0.18	15	112
TQ0166	3	14	2490	2010	2.1	0.3	185	49	0.1	366	< 5	25	660	5	6.47	0.47	0.22	51	102
TQ0167	1	4	3370	4740	1.7	0.5	165	39	0.3	582	< 5	36	1520	6	7.42	0.19	0.16	16	147
TQ0167	2	<2	4080	4880	1.6	0.6	192	44	0.3	589	< 5	38	1620	5	7.49	0.22	0.15	21	149
TQ0167	3	5	4400	5120	1.5	0.6	202	46	0.3	537	< 5	37	1640	6	7.51	0.24	0.24	31	161
TQ0168	1	< 2	2490	5120	1.8	1.8	246	37	0.2	584	< 5	33	1340	7	8.05	0.28	0.23	32	54
TQ0168	2	< 2	3600	8020	1.2	0.8	375	67	0.2	546	< 5	33	1230	7	8.84	0.85	0.07	51	41
TQ0168	3	< 2	3130	6710	0.9	0.5	318	41	0.3	647	< 5	39	932	9	8.82	0.26	0.09	15	48
TQ0169	1	16	2340	2950	1.3	0.4	145	43	0.2	486	< 5	33	741	7	7.45	0.25	0.23	22	58
TQ0169	2	13	2540	3120	1.3	0.4	131	46	0.2	430	< 5	30	722	7	7.5	0.41	0.21	33	65
TQ0169	3	9	2920	3610	1.4	0.5	147	36	0.2	441	< 5	30	743	7	7.67	0.32	0.26	9	79
TQ0170	1	15	2280	4350	0.9	0.3	176	31	0.2	641	< 5	40	859	8	7.24	0.12	0.13	6	94
TQ0170	2	14	2430	4530	0.9	0.3	186	32	0.2	672	< 5	42	971	9	7.15	0.12	0.09	7	81
TQ0170	3	12	2400	4460	1	0.3	194	32	0.3	705	< 5	43	1040	8	7	0.14	0.13	25	81
TQ0171	1	21	1660	4930	0.8	0.5	263	32	0.3	783	< 5	46	735	11	7.41	0.15	0.13	12	19
TQ0171	2	21	1700	4870	0.9	0.5	267	31	0.3	832	< 5	47	736	11	7.5	0.12	0.08	12	15
TQ0171	3	24	1660	5090	0.9	0.4	259	32	0.3	799	< 5	47	741	11	7.41	0.27	0.12	27	14
TQ0172	1	18	1820	3770	0.4	0.1	188	27	0.2	681	< 5	36	297	9	7.47	0.21	0.04	9	73
TQ0172	2	16	1570	2930	0.4	0.1	128	19	0.1	502	< 5	27	260	6	7.66	0.14	0.04	13	72
TQ0172	3	17	1500	5280	0.4	0.1	227	26	0.2	810	< 5	43	306	11	7.49	0.25	0.06	11	62
TQ0173	1	15	4310	1710	0.3	0.1	146	40	< 0.1	248	< 5	28	215	< 1	7.3	0.19	0.07	19	150
TQ0173	2	15	1850	1370	0.2	< 0.1	144	18	< 0.1	238	< 5	23	62	1	7.28	0.64	0.06	79	74
TQ0173	3	14	3190	1590	0.3	< 0.1	124	25	< 0.1	256	< 5	24	116	1	7.09	0.83	0.08	76	70
TQ0174	1	19	2570	2060	0.5	< 0.1	197	41	0.1	13	< 5	16	56	5	7.56	1.16	0.16	172	172
TQ0174	2	21	2620	2230	0.5	< 0.1	130	40	0.1	27	< 5	18	54	< 1	7.66	0.6	0.27	121	23
TQ0174	3	18	2510	2150	0.5	< 0.1	157	38	0.1	25	< 5	16	54	< 1	7.57	0.99	0.24	220	29

Table A2 continued.

Site	Rep	Available K (ug/g)	SO4 (ug/g)	Exchangeable Al (ug/g)	Exchangeable Ca (me/100g)	Exchangeable Fe (ug/g)	Exchangeable Mg (me/100g)	Exchangeable Mn (ug/g)	Exchangeable K (me/100g)	Exchangeable Na (me/100g)
TQ0164	1	419	46	670	38.3	990	5.9	130	1.2	< 0.01
TQ0164	2	116	33	2460	36	2360	4.4	230	0.4	< 0.01
TQ0164	3	167	87	730	38.7	1040	5.1	120	0.6	< 0.01
TQ0165	1	184	8.5	1790	27.8	1840	4.3	150	0.6	< 0.01
TQ0165	2	145	8	550	31.4	940	5.7	90	0.6	< 0.01
TQ0165	3	279	26	1610	26.7	1870	5	130	0.8	< 0.01
TQ0166	1	222	29	2940	35	2550	7.8	120	0.6	< 0.01
TQ0166	2	104	21	2850	36.2	2530	7.8	120	0.5	< 0.01
TQ0166	3	164	34	1860	39.6	1730	8.4	90	0.6	< 0.01
TQ0167	1	592	10	2620	37.6	2380	7.6	320	1.6	< 0.01
TQ0167	2	834	8.5	1000	42.1	1180	8.6	220	2.1	< 0.01
TQ0167	3	1020	9.1	2670	39.7	2400	8.9	320	2.5	< 0.01
TQ0168	1	975	12.3	640	30.3	710	10.2	190	2.2	< 0.01
TQ0168	2	2890	19.7	720	26.6	690	16.8	330	6.1	< 0.01
TQ0168	3	1380	7.5	660	27.5	670	12.5	180	3.1	< 0.01
TQ0169	1	225	23	3060	50	2940	8.7	200	0.6	< 0.01
TQ0169	2	321	37	1390	51.4	1710	8.9	170	0.8	< 0.01
TQ0169	3	680	23	2760	51.1	2730	10	280	1.6	< 0.01
TQ0170	1	217	10.7	1090	26.6	1470	5.9	80	0.6	< 0.01
TQ0170	2	157	13.3	3950	27.8	3550	5.8	120	0.5	< 0.01
TQ0170	3	236	8	5270	26.9	4480	5.6	130	0.6	< 0.01
TQ0171	1	99	11.7	1110	32.2	1530	9.3	70	0.4	< 0.01
TQ0171	2	96	11.7	1100	33.3	1530	9.6	70	0.4	< 0.01
TQ0171	3	113	14.9	1060	30.4	1520	8.8	80	0.4	< 0.01
TQ0172	1	376	3.8	1640	39.6	1570	16.9	110	1.8	< 0.01
TQ0172	2	506	4.6	1340	37	1500	14.4	130	2.3	< 0.01
TQ0172	3	288	4.3	1590	19.5	1640	7.5	100	0.7	< 0.01
TQ0173	1	37	14.4	1910	26.8	2210	7.1	130	0.2	< 0.01
TQ0173	2	122	9.1	350	16.4	960	4.3	100	0.4	< 0.01
TQ0173	3	112	19.2	1750	19.1	2150	5.8	140	0.4	< 0.01
TQ0174	1	1010	171	1470	40.4	1940	9.6	100	2.1	< 0.01
TQ0174	2	651	33	3710	46.1	3710	11.2	150	1.4	< 0.01
TQ0174	3	620	52	3950	46.8	3900	11.2	160	1.3	< 0.01

Table A3-1. Analysis results (µg/g dry weight) for replicate potato samples collected from garden sites, August 2002.

Site	Sample	Rep	Washed/Unwashed	Moisture (%)	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg
TQ0164	Potatoes	1	washed	80.57	22.7	< 0.1	0.3	1.4	< 0.02	10	0.47	704	< 0.1	< 0.1	17.4	65	0.3	1970	7.7	0.024
TQ0164	Potatoes	2	washed	80.11	8.9	< 0.1	0.2	1	< 0.02	9	0.35	547	< 0.1	< 0.1	14.3	41	0.2	1680	6.5	0.011
TQ0164	Potatoes	3	washed	80.51	9.9	< 0.1	0.2	0.9	< 0.02	8	0.37	479	< 0.1	< 0.1	14.7	42	0.2	1560	6.3	0.015
TQ0165	Potatoes	1	washed	83.59	8.3	< 0.1	< 0.1	0.7	< 0.02	7	0.34	517	< 0.1	< 0.1	8.2	37	< 0.1	1710	5.2	< 0.01
TQ0165	Potatoes	2	washed	83.73	21.8	< 0.1	< 0.1	1	< 0.02	7	0.39	448	< 0.1	< 0.1	10	53	0.3	1780	6.3	0.012
TQ0165	Potatoes	3	washed	85.28	28.5	< 0.1	< 0.1	1.5	< 0.02	9	0.46	709	< 0.1	< 0.1	11.4	67	0.3	1940	7	0.014
TQ0166	Potatoes	1	washed	77.51	5.9	< 0.1	< 0.1	0.9	< 0.02	9	0.29	463	< 0.1	< 0.1	3.9	33	< 0.1	1540	5.8	< 0.01
TQ0167	Potatoes	1	washed	83.04	11.2	< 0.1	< 0.1	0.8	< 0.02	8	0.3	393	< 0.1	< 0.1	7.2	38	< 0.1	1690	6.5	< 0.01
TQ0167	Potatoes	2	washed	81.98	12.8	< 0.1	< 0.1	1.1	< 0.02	8	0.23	535	< 0.1	< 0.1	6.9	37	< 0.1	1570	5.9	< 0.01
TQ0167	Potatoes	3	washed	83.07	9.2	< 0.1	< 0.1	1	< 0.02	8	0.37	483	< 0.1	< 0.1	9.7	39	< 0.1	1680	6	< 0.01
TQ0168	Potatoes	1	washed	86.62	37.8	< 0.1	< 0.1	3	< 0.02	9	0.37	762	0.2	< 0.1	16.6	92	0.2	2500	9.2	0.011
TQ0168	Potatoes	2	washed	86.70	20.8	< 0.1	< 0.1	2.1	< 0.02	10	0.3	508	< 0.1	< 0.1	14.6	71	< 0.1	2160	8	< 0.01
TQ0168	Potatoes	3	washed	84.54	18.3	< 0.1	< 0.1	1.9	< 0.02	8	0.16	404	< 0.1	< 0.1	11.1	60	< 0.1	1990	7.7	< 0.01
TQ0169	Potatoes	1	washed	79.07	8.5	< 0.1	< 0.1	0.4	< 0.02	7	0.18	216	< 0.1	< 0.1	7.2	34	< 0.1	1800	7.1	< 0.01
TQ0169	Potatoes	2	washed	78.11	7.7	< 0.1	< 0.1	0.7	< 0.02	7	0.17	314	< 0.1	< 0.1	6.4	35	< 0.1	1680	7.3	< 0.01
TQ0169	Potatoes	3	washed	80.41	5.6	< 0.1	< 0.1	0.5	< 0.02	6	0.16	258	< 0.1	< 0.1	7.2	31	< 0.1	1680	7.1	< 0.01
TQ0170	Potatoes	1	washed	81.28	20.3	< 0.1	< 0.1	1.5	< 0.02	9	0.36	464	< 0.1	< 0.1	9.8	51	< 0.1	1570	4.4	< 0.01
TQ0170	Potatoes	2	washed	75.31	10.2	< 0.1	< 0.1	0.8	< 0.02	6	0.34	232	< 0.1	< 0.1	9.1	33	< 0.1	1360	3.3	< 0.01
TQ0170	Potatoes	3	washed	88.58	10.6	< 0.1	< 0.1	0.8	< 0.02	8	0.3	276	< 0.1	< 0.1	8.4	35	< 0.1	1480	3.7	< 0.01
TQ0171	Potatoes	1	washed	80.16	20.7	< 0.1	< 0.1	1.4	< 0.02	7	0.29	405	< 0.1	< 0.1	10	40	< 0.1	1640	3.4	< 0.01
TQ0171	Potatoes	2	washed	80.77	11.4	< 0.1	< 0.1	1.7	< 0.02	7	0.27	512	< 0.1	< 0.1	9	30	< 0.1	1690	3.6	< 0.01
TQ0171	Potatoes	3	washed	79.76	13.4	< 0.1	< 0.1	1.1	< 0.02	7	0.22	383	< 0.1	< 0.1	8	35	< 0.1	1450	3.4	< 0.01
TQ0172	Potatoes	1	washed	81.57	29	< 0.1	< 0.1	1.4	< 0.02	8	0.11	558	0.1	< 0.1	6.5	52	< 0.1	1880	5.2	< 0.01
TQ0172	Potatoes	2	washed	79.29	26.4	< 0.1	< 0.1	1.3	< 0.02	8	0.1	518	0.1	< 0.1	6.1	44	< 0.1	1820	3	< 0.01
TQ0172	Potatoes	3	washed	81.58	42.5	< 0.1	< 0.1	1.6	< 0.02	7	0.1	492	0.1	< 0.1	6.6	62	< 0.1	1690	4.9	< 0.01
TQ0173	Potatoes	1	washed	82.30	20.1	< 0.1	< 0.1	0.6	< 0.02	7	0.08	431	< 0.1	< 0.1	6.3	55	0.3	1460	6.6	< 0.01
TQ0173	Potatoes	2	washed	82.37	12.2	< 0.1	< 0.1	0.6	< 0.02	7	0.08	468	< 0.1	< 0.1	6.7	47	< 0.1	1520	6.7	< 0.01
TQ0173	Potatoes	3	washed	85.26	21.7	< 0.1	< 0.1	1.1	< 0.02	8	0.09	697	< 0.1	< 0.1	8.6	67	< 0.1	1850	9.1	< 0.01
TQ0174	Potatoes	1	washed	84.58	11.4	< 0.1	< 0.1	0.6	< 0.02	7	0.12	600	< 0.1	< 0.1	9	46	< 0.1	1480	6.9	< 0.01
TQ0174	Potatoes	2	washed	85.47	13.2	< 0.1	< 0.1	0.8	< 0.02	7	0.09	602	< 0.1	< 0.1	8.9	47	< 0.1	1610	6.3	< 0.01
TQ0174	Potatoes	3	washed	85.01	11	< 0.1	< 0.1	0.8	< 0.02	7	0.09	491	< 0.1	< 0.1	8.8	41	0.2	1530	5.4	< 0.01

Table A3-1 continued.

Site	Sample	Rep	Washed/Unwashed	Moisture (%)	Mo	Ni	PO4	K	Se	SiO2	Ag	Na	Sr	S	Te	Tl	Sn	Ti	U	V	Zn	Zr
TQ0164	Potatoes	1	washed	80.57	1.1	< 0.1	6560	31000	4	202	< 0.01	61	2.08	2170	< 0.1	< 0.02	< 0.1	4	< 0.04	< 0.5	42.4	< 3
TQ0164	Potatoes	2	washed	80.11	1	< 0.1	5540	30200	4.9	178	< 0.01	82	1.74	1860	< 0.1	< 0.02	< 0.1	2.8	< 0.04	< 0.5	35.4	< 3
TQ0164	Potatoes	3	washed	80.51	1	< 0.1	5530	30400	5.7	177	< 0.01	52	1.51	2010	< 0.1	< 0.02	< 0.1	2.8	< 0.04	< 0.5	38.1	< 3
TQ0165	Potatoes	1	washed	83.59	1.3	< 0.1	6180	28600	< 0.2	206	< 0.01	12	1.43	1570	< 0.1	< 0.02	< 0.1	2.9	< 0.04	< 0.5	22.2	< 3
TQ0165	Potatoes	2	washed	83.73	1.6	< 0.1	6400	30800	< 0.2	182	< 0.01	8	1.39	1760	< 0.1	< 0.02	< 0.1	3.8	< 0.04	< 0.5	25.6	< 3
TQ0165	Potatoes	3	washed	85.28	1.3	< 0.1	7430	30700	< 0.2	242	< 0.01	20	2.03	1890	< 0.1	< 0.02	< 0.1	4.5	< 0.04	< 0.5	31.6	< 3
TQ0166	Potatoes	1	washed	77.51	0.5	< 0.1	3710	22400	< 0.2	96	< 0.01	29	1.86	1830	< 0.1	< 0.02	< 0.1	1.8	< 0.04	< 0.5	24.8	< 3
TQ0167	Potatoes	1	washed	83.04	0.8	< 0.1	6680	32000	< 0.2	229	< 0.01	20	1.34	1500	< 0.1	< 0.02	< 0.1	3.3	< 0.04	< 0.5	22.6	< 3
TQ0167	Potatoes	2	washed	81.98	0.8	< 0.1	6170	28300	0.3	212	< 0.01	22	1.94	1440	< 0.1	< 0.02	< 0.1	3.3	< 0.04	< 0.5	20.5	< 3
TQ0167	Potatoes	3	washed	83.07	0.8	< 0.1	7240	31900	0.3	148	< 0.01	23	1.67	1570	< 0.1	< 0.02	< 0.1	3.4	< 0.04	< 0.5	25.7	< 3
TQ0168	Potatoes	1	washed	86.62	0.8	0.2	7430	37700	0.6	169	< 0.01	79	3.04	2410	< 0.1	< 0.02	< 0.1	4.3	< 0.04	< 0.5	37	< 3
TQ0168	Potatoes	2	washed	86.70	0.9	0.1	7530	39600	0.4	206	< 0.01	54	2	2130	< 0.1	< 0.02	< 0.1	4.1	< 0.04	< 0.5	34.4	< 3
TQ0168	Potatoes	3	washed	84.54	0.6	0.2	5720	32100	0.4	177	< 0.01	67	1.74	1740	< 0.1	< 0.02	< 0.1	3.3	< 0.04	< 0.5	24	< 3
TQ0169	Potatoes	1	washed	79.07	0.8	< 0.1	4860	30600	< 0.2	154	< 0.01	10	0.53	1640	< 0.1	< 0.02	< 0.1	2.3	< 0.04	< 0.5	20.3	< 3
TQ0169	Potatoes	2	washed	78.11	0.7	< 0.1	4930	26700	< 0.2	118	0.02	11	0.84	1710	< 0.1	< 0.02	< 0.1	2.2	< 0.04	< 0.5	20.6	< 3
TQ0169	Potatoes	3	washed	80.41	0.7	0.5	5610	28400	< 0.2	117	0.01	10	0.64	1980	< 0.1	< 0.02	< 0.1	2.4	< 0.04	< 0.5	22	< 3
TQ0170	Potatoes	1	washed	81.28	0.6	0.2	3940	22800	< 0.2	126	< 0.01	14	1.47	1960	< 0.1	< 0.02	< 0.1	2.7	< 0.04	< 0.5	29.8	< 3
TQ0170	Potatoes	2	washed	75.31	0.5	< 0.1	3950	21700	< 0.2	107	< 0.01	4	0.74	1770	< 0.1	< 0.02	< 0.1	2.1	< 0.04	< 0.5	24.9	< 3
TQ0170	Potatoes	3	washed	88.58	0.5	0.1	4210	24500	< 0.2	128	< 0.01	8	0.83	1710	< 0.1	< 0.02	< 0.1	2.2	< 0.04	< 0.5	23.7	< 3
TQ0171	Potatoes	1	washed	80.16	0.7	< 0.1	3810	19700	0.3	114	< 0.01	7	1.19	2160	< 0.1	< 0.02	< 0.1	2.9	< 0.04	< 0.5	24.8	< 3
TQ0171	Potatoes	2	washed	80.77	0.6	< 0.1	3410	20100	0.3	88	< 0.01	10	1.55	2020	< 0.1	< 0.02	< 0.1	2.1	< 0.04	< 0.5	21.8	< 3
TQ0171	Potatoes	3	washed	79.76	0.6	< 0.1	3840	19300	0.3	151	< 0.01	10	1.03	1780	< 0.1	< 0.02	< 0.1	2.3	< 0.04	< 0.5	23.3	< 3
TQ0172	Potatoes	1	washed	81.57	0.6	0.1	5940	28300	< 0.2	200	< 0.01	13	1.83	1540	< 0.1	< 0.02	< 0.1	4	< 0.04	< 0.5	15.5	< 3
TQ0172	Potatoes	2	washed	79.29	0.5	< 0.1	6210	27300	< 0.2	283	< 0.01	9	1.45	1350	< 0.1	< 0.02	< 0.1	4	< 0.04	< 0.5	14.5	< 3
TQ0172	Potatoes	3	washed	81.58	0.6	0.1	5950	26200	< 0.2	146	< 0.01	13	1.66	1620	< 0.1	< 0.02	< 0.1	3.9	< 0.04	< 0.5	16	< 3
TQ0173	Potatoes	1	washed	82.30	1	0.2	4980	25400	< 0.2	160	< 0.01	17	1.23	1670	< 0.1	< 0.02	< 0.1	2.7	< 0.04	< 0.5	20.2	< 3
TQ0173	Potatoes	2	washed	82.37	1	0.1	5270	24500	< 0.2	162	< 0.01	20	1.4	1770	< 0.1	< 0.02	< 0.1	2.5	< 0.04	< 0.5	23.8	< 3
TQ0173	Potatoes	3	washed	85.26	1.3	0.2	6780	27200	< 0.2	164	< 0.01	23	2.27	2130	< 0.1	< 0.02	< 0.1	3.6	< 0.04	< 0.5	30.8	< 3
TQ0174	Potatoes	1	washed	84.58	0.9	0.3	4910	34400	< 0.2	143	< 0.01	73	2.21	1880	< 0.1	< 0.02	< 0.1	2.1	< 0.04	< 0.5	22.1	< 3
TQ0174	Potatoes	2	washed	85.47	0.8	0.2	4940	35700	< 0.2	189	< 0.01	64	2.29	1960	< 0.1	< 0.02	< 0.1	2.2	< 0.04	< 0.5	23.1	< 3
TQ0174	Potatoes	3	washed	85.01	0.8	0.2	4890	31500	< 0.2	133	0.01	38	1.89	1920	< 0.1	< 0.02	< 0.1	2.2	< 0.04	< 0.5	22.9	< 3

Table A3-2. Analysis results (µg/g dry weight) for replicate carrot samples collected from garden sites, August 2002.

Site	Sample	Rep	Washed/Unwashed	Moisture (%)	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg
TQ0164	Carrots	1	washed	88.11	27.4	< 0.1	0.5	4.9	< 0.02	25	0.63	2260	< 0.1	< 0.1	8.1	49	0.7	1570	8.5	0.054
TQ0164	Carrots	2	washed	87.69	30.9	< 0.1	0.4	5.5	< 0.02	28	0.58	2240	< 0.1	< 0.1	8.3	54	0.7	1680	7.8	0.058
TQ0164	Carrots	3	washed	86.66	31.8	< 0.1	0.5	5.7	< 0.02	29	0.73	2610	< 0.1	< 0.1	9.4	57	0.8	1810	9.9	0.053
TQ0165	Carrots	1	washed	90.93	29.9	< 0.1	0.2	9.7	< 0.02	28	0.54	2580	< 0.1	< 0.1	5.7	46	0.6	1890	3.5	0.026
TQ0165	Carrots	2	washed	91.45	33.3	< 0.1	0.2	9.5	< 0.02	30	0.4	2650	< 0.1	< 0.1	5.7	45	0.6	1950	3.9	0.026
TQ0165	Carrots	3	washed	91.09	31.3	< 0.1	0.2	10	< 0.02	27	0.34	2620	< 0.1	< 0.1	5.4	48	0.6	1810	4.3	0.031
TQ0166	Carrots	1	washed	90.15	23.4	< 0.1	0.2	8.6	< 0.02	29	0.32	2330	< 0.1	< 0.1	6.7	39	0.2	1880	5	0.025
TQ0166	Carrots	2	washed	91.37	22.4	< 0.1	0.2	9.5	< 0.02	30	0.36	2670	< 0.1	< 0.1	6.5	41	0.2	1810	5.2	0.023
TQ0166	Carrots	3	washed	91.28	26.3	< 0.1	0.2	8.1	< 0.02	31	0.38	2620	< 0.1	< 0.1	7.2	41	0.3	1760	5.7	0.026
TQ0167	Carrots	1	washed	91.82	57.5	< 0.1	0.2	9.1	< 0.02	30	0.54	2990	< 0.1	< 0.1	6.1	69	0.4	2110	5.4	0.018
TQ0167	Carrots	2	washed	91.9	70.6	< 0.1	0.2	9.8	< 0.02	29	0.38	3270	< 0.1	< 0.1	5.3	90	0.5	1910	6.6	0.021
TQ0167	Carrots	3	washed	91.61	63.6	< 0.1	0.3	9.4	< 0.02	25	0.59	2870	< 0.1	< 0.1	5.5	83	0.4	1780	5.7	0.018
TQ0168	Carrots	1	washed	91.65	45.3	< 0.1	< 0.1	14.6	< 0.02	28	0.48	2420	< 0.1	< 0.1	7.7	71	0.3	2080	5.1	0.022
TQ0168	Carrots	2	washed	91.82	60.5	< 0.1	< 0.1	15.1	< 0.02	30	0.48	2410	0.1	< 0.1	8.5	87	0.4	2070	5.1	0.026
TQ0168	Carrots	3	washed	92.02	88.2	< 0.1	0.1	13.5	< 0.02	34	0.54	2530	0.1	< 0.1	8.2	124	0.4	2160	6.6	0.027
TQ0169	Carrots	1	washed	87.27	30.1	< 0.1	0.1	17.4	< 0.02	21	0.41	2300	< 0.1	< 0.1	4.9	44	0.2	1830	5.9	0.016
TQ0169	Carrots	2	washed	87.31	28.7	< 0.1	< 0.1	16.9	< 0.02	26	0.4	2520	< 0.1	< 0.1	5.7	37	0.2	2290	6.1	0.014
TQ0169	Carrots	3	washed	88.57	20.7	< 0.1	< 0.1	17.6	< 0.02	27	0.39	2500	< 0.1	< 0.1	5.3	36	0.1	2220	7	0.015
TQ0170	Carrots	1	washed	89.71	44.9	< 0.1	< 0.1	10.7	< 0.02	23	0.3	2120	< 0.1	< 0.1	6.9	58	0.1	1750	4.6	0.015
TQ0170	Carrots	2	washed	90.14	52.3	< 0.1	0.1	14.8	< 0.02	24	0.36	2300	< 0.1	< 0.1	7.1	67	0.2	1780	4.9	0.015
TQ0170	Carrots	3	washed	90.4	26.4	< 0.1	< 0.1	11.6	< 0.02	26	0.27	2130	< 0.1	< 0.1	6.3	37	< 0.1	1880	3.9	0.011
TQ0171	Carrots	1	washed	90.21	105	< 0.1	< 0.1	15.4	< 0.02	20	0.45	2360	0.2	< 0.1	8	132	0.2	2230	4.5	0.018
TQ0171	Carrots	2	washed	89.99	45.7	< 0.1	< 0.1	12.8	< 0.02	22	0.46	2160	< 0.1	< 0.1	6.8	55	0.1	2050	2.9	0.014
TQ0171	Carrots	3	washed	90.52	41.7	< 0.1	< 0.1	12.7	< 0.02	16	0.28	2140	< 0.1	< 0.1	5.9	52	0.1	1490	2.8	0.012
TQ0172	Carrots	1	washed	92	123	< 0.1	< 0.1	17.2	< 0.02	28	0.42	2980	0.2	< 0.1	4.4	136	< 0.1	2880	5	0.016
TQ0172	Carrots	2	washed	91.61	183	< 0.1	< 0.1	14.4	< 0.02	25	0.36	2930	0.4	< 0.1	4.3	199	0.1	2960	5.2	0.015
TQ0172	Carrots	3	washed	91.69	96.6	< 0.1	< 0.1	10.9	< 0.02	23	0.35	2780	0.2	< 0.1	3.9	112	< 0.1	2300	4.6	0.011
TQ0173	Carrots	1	washed	90.67	21	< 0.1	< 0.1	7.8	< 0.02	20	0.09	2200	< 0.1	< 0.1	3.8	33	< 0.1	1730	3.8	< 0.01
TQ0173	Carrots	2	washed	91.67	29.6	< 0.1	< 0.1	9.3	< 0.02	24	0.12	2720	< 0.1	< 0.1	3.6	52	0.1	2410	4.6	< 0.01
TQ0173	Carrots	3	washed	91.67	33.1	< 0.1	< 0.1	9.1	< 0.02	28	0.15	2710	< 0.1	< 0.1	4.5	60	0.1	2370	4	< 0.01
TQ0174	Carrots	1	washed	83	16.8	< 0.1	< 0.1	7.9	< 0.02	32	0.08	2330	< 0.1	< 0.1	8.8	54	< 0.1	3020	6.8	< 0.01
TQ0174	Carrots	2	washed	85.07	22.9	< 0.1	< 0.1	5.3	< 0.02	27	0.07	2220	< 0.1	< 0.1	8.3	55	< 0.1	2510	6.2	< 0.01
TQ0174	Carrots	3	washed	85.77	10.4	< 0.1	< 0.1	5.1	< 0.02	29	0.07	2350	< 0.1	< 0.1	7.1	37	< 0.1	2810	5.3	< 0.01

Table A3-2 continued.

Site	Sample	Rep	Washed/Unwashed	Moisture (%)	Mo	Ni	PO4	K	Se	SiO2	Ag	Na	Sr	S	Te	Tl	Sn	Ti	U	V	Zn	Zr
TQ0164	Carrots	1	washed	88.11	0.2	0.2	9370	25400	2.2	129	< 0.01	4250	11	582	< 0.1	< 0.02	< 0.1	3.5	< 0.04	< 0.5	56	< 3
TQ0164	Carrots	2	washed	87.69	0.2	0.1	9920	24400	2.1	150	< 0.01	4850	10.4	609	< 0.1	< 0.02	< 0.1	3.8	< 0.04	< 0.5	56.2	< 3
TQ0164	Carrots	3	washed	86.66	0.2	0.2	10900	215000	2.6	149	< 0.01	4930	12.7	544	< 0.1	< 0.02	< 0.1	4.1	< 0.04	< 0.5	64.9	< 3
TQ0165	Carrots	1	washed	90.93	0.4	< 0.1	10500	32100	< 0.2	153	< 0.01	2340	9.32	825	< 0.1	< 0.02	< 0.1	3.8	< 0.04	< 0.5	35.8	< 3
TQ0165	Carrots	2	washed	91.45	0.4	0.1	10200	32700	< 0.2	145	< 0.01	2500	9.34	723	< 0.1	< 0.02	< 0.1	3.8	< 0.04	< 0.5	38.8	< 3
TQ0165	Carrots	3	washed	91.09	0.6	0.1	10300	33400	< 0.2	137	< 0.01	2110	9.23	975	< 0.1	< 0.02	< 0.1	4	< 0.04	< 0.5	35.7	< 3
TQ0166	Carrots	1	washed	90.15	< 0.1	0.2	7340	24500	< 0.2	137	< 0.01	4580	10.8	646	< 0.1	< 0.02	< 0.1	2.7	< 0.04	< 0.5	53.2	< 3
TQ0166	Carrots	2	washed	91.37	0.1	0.2	8480	27900	< 0.2	137	< 0.01	5840	12.2	729	< 0.1	< 0.02	< 0.1	2.9	< 0.04	< 0.5	53.1	< 3
TQ0166	Carrots	3	washed	91.28	0.1	0.2	8220	30100	< 0.2	123	< 0.01	4770	12.1	826	< 0.1	< 0.02	< 0.1	2.9	< 0.04	< 0.5	59.1	< 3
TQ0167	Carrots	1	washed	91.82	0.4	0.2	12700	39300	< 0.2	180	< 0.01	1440	14.1	780	< 0.1	< 0.02	< 0.1	6.4	< 0.04	< 0.5	46.6	< 3
TQ0167	Carrots	2	washed	91.9	0.3	0.2	11700	13400	< 0.2	110	< 0.01	1070	16.2	814	< 0.1	< 0.02	< 0.1	7.4	< 0.04	< 0.5	51	< 3
TQ0167	Carrots	3	washed	91.61	0.3	0.2	12200	38200	< 0.2	117	< 0.01	1160	13.8	783	< 0.1	< 0.02	< 0.1	7.2	< 0.04	< 0.5	45.1	< 3
TQ0168	Carrots	1	washed	91.65	0.2	0.8	8720	42900	0.3	99	< 0.01	1140	11.2	1370	< 0.1	< 0.02	< 0.1	5.5	< 0.04	< 0.5	41	< 3
TQ0168	Carrots	2	washed	91.82	0.2	0.3	8500	39800	0.3	113	< 0.01	919	11.1	649	< 0.1	< 0.02	< 0.1	6.1	< 0.04	< 0.5	35.5	< 3
TQ0168	Carrots	3	washed	92.02	0.2	0.3	8670	36200	0.3	164	< 0.01	971	11.5	593	< 0.1	< 0.02	< 0.1	7.9	< 0.04	< 0.5	38.7	< 3
TQ0169	Carrots	1	washed	87.27	0.1	0.1	6970	23700	< 0.2	113	< 0.01	1470	9.17	452	< 0.1	< 0.02	< 0.1	3.3	< 0.04	< 0.5	25	< 3
TQ0169	Carrots	2	washed	87.31	0.1	0.2	8430	25700	< 0.2	139	< 0.01	2500	9.65	1110	< 0.1	< 0.02	< 0.1	3.2	< 0.04	< 0.5	28.4	< 3
TQ0169	Carrots	3	washed	88.57	0.1	0.2	8690	26100	< 0.2	130	< 0.01	2630	9.71	613	< 0.1	< 0.02	< 0.1	3	< 0.04	< 0.5	28.3	< 3
TQ0170	Carrots	1	washed	89.71	< 0.1	0.5	6890	18000	< 0.2	111	< 0.01	4490	8.08	549	< 0.1	< 0.02	< 0.1	4	< 0.04	< 0.5	36.1	< 3
TQ0170	Carrots	2	washed	90.14	< 0.1	0.4	8040	20400	< 0.2	114	< 0.01	5240	9.67	691	< 0.1	< 0.02	< 0.1	4.6	< 0.04	< 0.5	45.1	< 3
TQ0170	Carrots	3	washed	90.4	< 0.1	0.5	8050	18200	< 0.2	114	< 0.01	4380	7.99	649	< 0.1	< 0.02	< 0.1	3.2	< 0.04	< 0.5	35.5	< 3
TQ0171	Carrots	1	washed	90.21	0.2	0.2	6360	19400	< 0.2	116	< 0.01	3460	7.86	1190	< 0.1	< 0.02	< 0.1	8.3	< 0.04	< 0.5	30	< 3
TQ0171	Carrots	2	washed	89.99	0.1	0.1	6610	19600	< 0.2	102	< 0.01	3370	7.26	516	< 0.1	< 0.02	< 0.1	4.4	< 0.04	< 0.5	24.5	< 3
TQ0171	Carrots	3	washed	90.52	0.1	0.1	5710	15200	< 0.2	95	< 0.01	2600	6.1	548	< 0.1	< 0.02	< 0.1	3.9	< 0.04	< 0.5	24.2	< 3
TQ0172	Carrots	1	washed	92	0.2	0.2	12200	41700	< 0.2	137	< 0.01	514	11.4	1410	< 0.1	< 0.02	< 0.1	7.7	< 0.04	< 0.5	27.2	< 3
TQ0172	Carrots	2	washed	91.61	0.2	0.3	12200	39500	< 0.2	156	< 0.01	670	12.1	1310	< 0.1	< 0.02	< 0.1	9.3	< 0.04	0.6	28.4	< 3
TQ0172	Carrots	3	washed	91.69	0.2	0.2	11000	35600	< 0.2	124	< 0.01	416	10.1	637	< 0.1	< 0.02	< 0.1	8.3	< 0.04	< 0.5	26.1	< 3
TQ0173	Carrots	1	washed	90.67	0.2	0.1	7770	24900	< 0.2	98	< 0.01	5350	6.9	556	< 0.1	< 0.02	< 0.1	2.9	< 0.04	< 0.5	16.9	< 3
TQ0173	Carrots	2	washed	91.67	0.3	0.1	8960	31900	< 0.2	131	< 0.01	5350	8.76	1260	< 0.1	< 0.02	< 0.1	3.4	< 0.04	< 0.5	20.5	< 3
TQ0173	Carrots	3	washed	91.67	0.3	0.1	9840	29600	< 0.2	155	< 0.01	6410	8.97	783	< 0.1	< 0.02	< 0.1	3.8	< 0.04	< 0.5	21.7	< 3
TQ0174	Carrots	1	washed	83	0.3	0.4	10600	30300	< 0.2	190	< 0.01	1900	8.67	1230	< 0.1	< 0.02	< 0.1	2.8	< 0.04	< 0.5	25.2	< 3
TQ0174	Carrots	2	washed	85.07	0.3	0.4	9830	27800	< 0.2	176	< 0.01	1930	7.54	1330	< 0.1	< 0.02	< 0.1	3.1	< 0.04	< 0.5	23.3	< 3
TQ0174	Carrots	3	washed	85.77	0.2	0.3	9490	26200	< 0.2	176	< 0.01	1900	8.48	1170	< 0.1	< 0.02	< 0.1	2.4	< 0.04	< 0.5	21.7	< 3

Table A3-3. Analysis results (µg/g dry weight) for replicate bean samples collected from garden sites, August 2002.

Site	Sample	Rep	Washed/Unwashed	Moisture (%)	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg
TQ0164	Beans	1	unwashed	88.07	59.7	<0.1	0.7	5.0	<0.02	40	0.21	10900	<0.1	<0.1	10.8	115	0.6	3550	12.0	0.034
TQ0164	Beans	2	unwashed	88.08	44.2	<0.1	0.6	5.3	<0.02	44	0.26	13200	<0.1	<0.1	9.9	93	0.7	3720	10.9	0.036
TQ0164	Beans	3	unwashed	87.85	38.7	<0.1	0.6	4.8	<0.02	43	0.21	11800	<0.1	<0.1	9.5	110	0.5	3580	11.0	0.027
TQ0164	Beans	1	washed	87.64	19.2	<0.1	0.9	4.8	< 0.02	35	0.17	10000	0.3	< 0.1	11.5	140	0.6	3360	15.1	0.013
TQ0164	Beans	2	washed	87.91	24.2	<0.1	0.5	4.0	<0.02	40	0.19	10300	<0.1	<0.1	9.0	89	0.3	3420	10.8	0.017
TQ0164	Beans	3	washed	87.26	20.9	<0.1	0.5	4.1	<0.02	33	0.17	9620	<0.1	<0.1	8.4	69	0.3	3150	10.4	0.014
TQ0165	Beans	1	unwashed	92.76	18.4	<0.1	0.1	6.0	<0.02	39	0.29	12100	<0.1	<0.1	8.9	86	0.5	5050	11.4	0.013
TQ0165	Beans	2	unwashed	92.77	9.3	<0.1	0.1	5.0	<0.02	36	0.24	11300	<0.1	<0.1	8.8	88	0.3	4810	10.6	0.01
TQ0165	Beans	3	unwashed	92.7	16.1	<0.1	0.1	5.3	<0.02	41	0.25	11700	<0.1	<0.1	9.2	100	0.4	5090	12.1	0.013
TQ0165	Beans	1	washed	92.96	10.8	<0.1	0.1	5.5	<0.02	40	0.24	12400	<0.1	<0.1	8.1	89	0.3	5430	11.4	0.011
TQ0165	Beans	2	washed	93.25	9.7	<0.1	0.1	5.6	<0.02	36	0.26	11600	<0.1	<0.1	9.0	71	0.3	4940	9.9	0.014
TQ0165	Beans	3	washed	93.24	15.3	<0.1	0.1	5.7	<0.02	42	0.23	12400	<0.1	<0.1	8.6	87	0.3	5640	9.7	0.014
TQ0166	Beans	1	unwashed	93.05	36.5	<0.1	0.2	11.2	<0.02	46	0.22	10900	<0.1	<0.1	8.7	91	0.3	4520	12.9	0.016
TQ0166	Beans	2	unwashed	93.06	42.3	<0.1	0.2	10.7	<0.02	53	0.23	11300	0.1	<0.1	6.4	96	0.4	4970	10.8	0.022
TQ0166	Beans	3	unwashed	92.85	42.8	<0.1	0.2	10.6	<0.02	40	0.23	10500	0.1	<0.1	7.2	88	0.4	4160	11.1	0.021
TQ0166	Beans	1	washed	92.6	22.6	<0.1	0.1	8.9	<0.02	34	0.21	8770	<0.1	<0.1	6.9	65	0.3	4020	9.2	0.012
TQ0166	Beans	2	washed	92.74	22.5	<0.1	0.1	10.5	<0.02	37	0.25	10400	<0.1	<0.1	6.6	67	0.3	4250	10.0	0.015
TQ0166	Beans	3	washed	92.5	18.9	<0.1	0.2	9.5	<0.02	39	0.20	10400	<0.1	<0.1	5.8	62	0.2	4480	9.4	< 0.01
TQ0167	Beans	1	unwashed	92.57	17.1	<0.1	0.2	13.0	<0.02	42	0.27	11800	<0.1	<0.1	7.3	76	0.4	4330	20.5	< 0.01
TQ0167	Beans	2	unwashed	93	16.5	<0.1	0.2	12.4	<0.02	45	0.26	11700	<0.1	<0.1	7.2	91	0.4	4520	22.3	< 0.01
TQ0167	Beans	3	unwashed	92.77	18.6	<0.1	0.1	11.3	<0.02	38	0.26	10300	<0.1	<0.1	7.1	90	0.4	4030	22.1	< 0.01
TQ0167	Beans	1	washed	92.55	18.2	<0.1	0.1	12.0	<0.02	41	0.24	11000	<0.1	<0.1	6.2	83	0.3	4290	22.3	< 0.01
TQ0167	Beans	2	washed	92.59	11.2	<0.1	0.1	12.0	<0.02	43	0.23	11400	<0.1	<0.1	6.1	78	0.3	4520	22.3	< 0.01
TQ0167	Beans	3	washed	92.6	19.1	<0.1	0.1	11.1	<0.02	42	0.23	9840	<0.1	<0.1	6.2	76	0.3	4150	20.6	< 0.01
TQ0168	Beans	1	washed	93.75	31.8	<0.1	<0.1	16.9	0.08	44	0.32	9660	0.2	<0.1	11.5	108	0.3	5780	9.2	< 0.01
TQ0168	Beans	2	washed	93.5	29.1	<0.1	<0.1	16.8	<0.02	49	0.25	10300	0.2	<0.1	10.5	113	0.2	6180	9.0	< 0.01
TQ0168	Beans	3	washed	93.54	37.8	<0.1	<0.1	19.7	<0.02	51	0.28	11800	0.1	<0.1	10.6	115	0.3	6430	9.4	< 0.01
TQ0169	Beans	1	washed	90.03	8.1	<0.1	<0.1	12.1	<0.02	36	0.12	11500	<0.1	<0.1	5.6	62	0.2	4320	16.8	< 0.01
TQ0170	Beans	1	unwashed	92.13	73.7	<0.1	<0.1	7.8	<0.02	39	0.16	9120	0.2	<0.1	11.1	142	0.4	4720	9.2	< 0.01
TQ0170	Beans	2	unwashed	92.33	23.7	<0.1	<0.1	8.2	<0.02	45	0.15	9820	<0.1	<0.1	10.2	112	0.2	4920	8.9	< 0.01
TQ0170	Beans	3	unwashed	92.31	60.4	<0.1	0.2	8.4	0.05	40	0.21	9130	0.3	<0.1	11.9	142	0.4	4650	10.1	< 0.01
TQ0170	Beans	1	washed	92.08	18.8	<0.1	<0.1	8.8	<0.02	39	0.16	9530	<0.1	<0.1	9.5	88	0.2	4540	8.2	< 0.01
TQ0170	Beans	2	washed	92.09	61.0	<0.1	0.1	8.5	<0.02	42	0.18	10200	0.1	<0.1	11.6	128	0.3	4930	10.3	0.011
TQ0170	Beans	3	washed	92.24	20.8	<0.1	<0.1	7.9	<0.02	40	0.16	8520	<0.1	<0.1	10.1	93	0.2	4570	8.1	< 0.01
TQ0171	Beans	1	unwashed	91.73	31.0	<0.1	<0.1	6.8	<0.02	39	0.31	8700	<0.1	<0.1	9.1	73	0.3	4620	5.2	< 0.01
TQ0171	Beans	2	unwashed	91.63	21.4	<0.1	<0.1	6.0	<0.02	48	0.24	9040	<0.1	<0.1	8.6	88	0.2	5420	6.6	< 0.01
TQ0171	Beans	3	unwashed	91.1	22.6	<0.1	<0.1	6.5	<0.02	44	0.30	8500	<0.1	<0.1	8.0	69	0.2	4810	5.2	< 0.01
TQ0171	Beans	1	washed	92.48	15.3	<0.1	<0.1	7.2	<0.02	43	0.25	9450	0.1	<0.1	8.8	76	0.1	5180	5.5	< 0.01
TQ0171	Beans	2	washed	91.52	15.0	<0.1	<0.1	5.9	<0.02	36	0.26	7900	0.1	<0.1	8.7	75	0.2	4410	5.6	< 0.01
TQ0171	Beans	3	washed	90.73	18.3	<0.1	<0.1	5.7	<0.02	35	0.25	7790	0.2	<0.1	8.3	78	0.2	4790	5.9	< 0.01
TQ0172	Beans	1	washed	93.51	59.1	<0.1	<0.1	9.2	<0.02	33	0.09	8490	0.1	<0.1	3.7	100	0.2	5350	13.6	< 0.01
TQ0173	Beans	1	unwashed	93.18	9.8	<0.1	<0.1	6.0	<0.02	34	0.04	8070	<0.1	<0.1	6.4	54	<0.1	5240	9.0	< 0.01
TQ0173	Beans	2	unwashed	93.33	11.2	<0.1	<0.1	5.4	<0.02	38	0.04	9070	<0.1	<0.1	6.7	74	<0.1	5880	10.1	< 0.01
TQ0173	Beans	3	unwashed	93.19	30.7	<0.1	<0.1	6.5	<0.02	34	0.04	8460	<0.1	<0.1	6.2	80	<0.1	5230	9.9	< 0.01
TQ0173	Beans	1	washed	93.33	4.9	<0.1	<0.1	4.9	<0.02	38	0.04	9090	<0.1	<0.1	6.9	79	<0.1	6500	10.8	< 0.01
TQ0173	Beans	2	washed	93.27	5.5	<0.1	<0.1	5.0	<0.02	38	0.04	9310	<0.1	<0.1	6.7	72	<0.1	6180	9.9	< 0.01
TQ0173	Beans	3	washed	93.04	5.5	<0.1	<0.1	4.6	<0.02	38	0.04	8530	<0.1	<0.1	6.8	75	<0.1	6200	10.1	< 0.01
TQ0174	Beans	1	unwashed	88.16	24.3	<0.1	<0.1	6.0	0.03	41	0.05	9830	<0.1	<0.1	4.3	71	0.2	4790	13.2	< 0.01
TQ0174	Beans	2	unwashed	88.49	31.2	<0.1	<0.1	5.6	<0.02	35	0.04	8140	<0.1	<0.1	4.5	66	0.3	4300	12.1	< 0.01
TQ0174	Beans	3	unwashed	89.05	16.4	<0.1	<0.1	5.4	<0.02	31	0.04	7940	<0.1	<0.1	4.6	46	0.1	3850	11.8	< 0.01
TQ0174	Beans	1	washed	87.92	12.6	<0.1	<0.1	4.4	<0.02	31	0.04	7090	<0.1	<0.1	4.9	58	0.7	4110	12.0	< 0.01
TQ0174	Beans	2	washed	89.54	15.4	<0.1	<0.1	5.6	0.03	33	0.04	8670	<0.1	<0.1	4.1	38	1.1	4260	11.4	< 0.01
TQ0174	Beans	3	washed	88.39	13.7	<0.1	<0.1	4.6	<0.02	41	0.04	8250	<0.1	<0.1	4.7	66	0.8	4720	13.6	< 0.01

Table A3-3 continued.

Site	Sample	Rep	Washed/Unwashed	Moisture (%)	Mo	Ni	PO4	K	Se	SiO2	Ag	Na	Sr	S	Te	Tl	Sn	Ti	U	V	Zn	Zr
TQ0164	Beans	1	unwashed	88.07	11.0	0.8	19700	36600	10.6	703	<0.01	20	23.6	2630	<0.1	<0.02	1.8	9.2	<0.04	<0.5	54.8	<3
TQ0164	Beans	2	unwashed	88.08	10.2	0.8	18000	37300	9.9	776	<0.01	20	30.8	2910	<0.1	<0.02	1.5	8.0	<0.04	<0.5	54.6	<3
TQ0164	Beans	3	unwashed	87.85	11.5	0.7	18200	36200	10.2	789	<0.01	19	25.6	2120	<0.1	<0.02	1.4	8.3	<0.04	<0.5	52.9	<3
TQ0164	Beans	1	washed	87.64	14.6	0.6	17900	30200	8.8	307	< 0.01	21	24.5	2350	< 0.1	< 0.02	< 0.1	3.8	< 0.04	< 0.5	59.1	< 3
TQ0164	Beans	2	washed	87.91	11.3	0.7	18000	33000	10.7	592	<0.01	19	22.3	2060	<0.1	<0.02	1.1	8.0	<0.04	<0.5	48.7	<3
TQ0164	Beans	3	washed	87.26	9.1	0.7	17500	34500	9.5	544	<0.01	16	22.5	1960	<0.1	<0.02	2.4	7.0	<0.04	<0.5	45.0	<3
TQ0165	Beans	1	unwashed	92.78	16.3	0.6	25300	47600	<0.2	749	<0.01	11	21.2	2610	<0.1	<0.02	1.1	9.3	<0.04	<0.5	45.7	<3
TQ0165	Beans	2	unwashed	92.77	20.4	0.5	27000	47900	<0.2	773	<0.01	11	19.2	2340	<0.1	<0.02	0.4	8.9	<0.04	<0.5	41.3	<3
TQ0165	Beans	3	unwashed	92.7	19.5	0.5	28100	49400	<0.2	793	<0.01	14	18.8	2350	<0.1	<0.02	2.1	10.1	<0.04	<0.5	44.3	<3
TQ0165	Beans	1	washed	92.96	16.7	0.5	27500	52400	0.2	844	<0.01	19	20.0	2470	<0.1	<0.02	0.5	9.6	<0.04	<0.5	41.0	<3
TQ0165	Beans	2	washed	93.25	15.7	0.7	24400	43700	0.2	682	<0.01	13	20.3	2510	<0.1	<0.02	0.8	9.4	<0.04	<0.5	43.4	<3
TQ0165	Beans	3	washed	93.24	15.3	0.6	25800	47700	<0.2	787	<0.01	17	19.1	2870	<0.1	<0.02	1.1	10.5	<0.04	<0.5	49.9	<3
TQ0166	Beans	1	unwashed	93.05	2.4	0.7	26500	51200	<0.2	839	<0.01	22	31.0	2520	<0.1	<0.02	1.7	9.9	<0.04	<0.5	61.5	<3
TQ0166	Beans	2	unwashed	93.06	1.6	0.6	18100	49300	<0.2	801	<0.01	22	31.0	2400	<0.1	<0.02	1.8	8.2	<0.04	<0.5	53.9	<3
TQ0166	Beans	3	unwashed	92.85	1.9	0.6	22500	48300	<0.2	790	<0.01	22	31.2	2450	<0.1	<0.02	2.0	8.8	<0.04	<0.5	57.7	<3
TQ0166	Beans	1	washed	92.6	2.2	0.5	20600	42800	<0.2	603	<0.01	19	26.7	2350	<0.1	<0.02	2.1	7.6	<0.04	<0.5	54.0	<3
TQ0166	Beans	2	washed	92.74	2.1	0.6	19400	44100	<0.2	733	<0.01	21	30.2	2320	<0.1	<0.02	1.7	7.6	<0.04	<0.5	54.3	<3
TQ0166	Beans	3	washed	92.5	1.8	0.5	17500	44100	<0.2	743	<0.01	20	29.4	2420	<0.1	<0.02	1.4	6.6	<0.04	<0.5	53.1	<3
TQ0167	Beans	1	unwashed	92.57	19.0	0.4	20800	45700	<0.2	719	<0.01	13	30.9	2550	<0.1	<0.02	1.4	8.3	<0.04	<0.5	49.5	<3
TQ0167	Beans	2	unwashed	93	17.0	0.4	25400	54000	<0.2	792	<0.01	14	28.4	2510	<0.1	<0.02	0.9	8.7	<0.04	<0.5	52.4	<3
TQ0167	Beans	3	unwashed	92.77	15.9	0.3	21900	41900	<0.2	724	<0.01	9	25.5	2480	<0.1	<0.02	1.5	8.6	<0.04	<0.5	51.5	<3
TQ0167	Beans	1	washed	92.55	16.1	0.4	21000	43700	<0.2	765	<0.01	16	26.9	2340	<0.1	<0.02	1.5	8.8	<0.04	<0.5	48.6	<3
TQ0167	Beans	2	washed	92.59	16.7	0.4	20600	46300	<0.2	805	<0.01	14	27.6	2460	<0.1	<0.02	1.4	8.3	<0.04	<0.5	48.8	<3
TQ0167	Beans	3	washed	92.6	16.4	0.4	22000	44300	<0.2	763	<0.01	15	24.6	2420	<0.1	<0.02	1.5	8.6	<0.04	<0.5	50.3	<3
TQ0168	Beans	1	washed	93.75	9.1	0.8	28900	66100	0.6	578	<0.01	43	23.5	2890	<0.1	<0.02	2.6	10.1	<0.04	<0.5	69.2	<3
TQ0168	Beans	2	washed	93.5	8.1	0.7	23600	59600	0.4	777	<0.01	19	23.6	2650	<0.1	<0.02	3.4	10.1	<0.04	<0.5	63.3	<3
TQ0168	Beans	3	washed	93.54	8.4	0.7	23300	60600	0.4	767	<0.01	21	26.8	2810	<0.1	<0.02	2.1	10.0	<0.04	<0.5	68.8	<3
TQ0169	Beans	1	washed	90.03	5.5	0.5	14400	31900	<0.2	629	<0.01	10	22.7	2360	<0.1	<0.02	2.4	5.6	<0.04	<0.5	33.0	<3
TQ0170	Beans	1	unwashed	92.13	5.3	0.9	22300	37700	<0.2	740	<0.01	10	17.7	2250	<0.1	<0.02	1.0	10.4	<0.04	<0.5	54.4	<3
TQ0170	Beans	2	unwashed	92.33	5.3	1.0	23000	37500	<0.2	803	<0.01	13	18.6	2210	<0.1	<0.02	1.1	8.9	<0.04	<0.5	49.1	<3
TQ0170	Beans	3	unwashed	92.31	6.0	1.1	23400	38600	<0.2	710	<0.01	20	18.8	2380	<0.1	<0.02	1.4	10.3	<0.04	<0.5	57.3	<3
TQ0170	Beans	1	washed	92.08	4.9	0.9	21100	38400	<0.2	550	<0.01	11	21.1	2280	<0.1	<0.02	0.5	7.6	<0.04	<0.5	48.3	<3
TQ0170	Beans	2	washed	92.09	6.0	1.0	22700	41500	<0.2	596	<0.01	16	20.7	2450	<0.1	<0.02	0.9	9.5	<0.04	<0.5	52.2	<3
TQ0170	Beans	3	washed	92.24	5.4	0.8	23600	41300	<0.2	724	<0.01	10	17.2	2410	<0.1	<0.02	1.3	8.1	<0.04	<0.5	52.0	<3
TQ0171	Beans	1	unwashed	91.73	4.3	0.5	16600	36000	<0.2	636	<0.01	7	15.7	2020	<0.1	<0.02	1.1	7.1	<0.04	<0.5	44.1	<3
TQ0171	Beans	2	unwashed	91.63	5.0	0.4	19200	37600	<0.2	761	<0.01	10	12.5	2090	<0.1	<0.02	1.2	7.9	<0.04	<0.5	42.0	<3
TQ0171	Beans	3	unwashed	91.1	4.0	0.4	17900	38200	<0.2	652	<0.01	6	13.8	1960	<0.1	<0.02	1.1	6.4	<0.04	<0.5	38.5	<3
TQ0171	Beans	1	washed	92.48	4.8	0.5	18300	40100	<0.2	496	<0.01	14	16.5	2210	<0.1	<0.02	2.0	6.8	<0.04	<0.5	44.8	<3
TQ0171	Beans	2	washed	91.52	5.0	0.5	19000	32900	<0.2	559	<0.01	9	12.4	2050	<0.1	<0.02	3.0	6.9	<0.04	<0.5	43.6	<3
TQ0171	Beans	3	washed	90.73	4.6	0.5	16900	33000	<0.2	589	<0.01	12	12.8	2060	<0.1	<0.02	3.3	7.0	<0.04	<0.5	40.8	<3
TQ0172	Beans	1	washed	93.51	7.1	0.5	17000	39400	<0.2	614	<0.01	16	15.4	2150	<0.1	<0.02	0.5	8.0	<0.04	<0.5	40.9	<3
TQ0173	Beans	1	unwashed	93.18	5.0	0.6	21400	42400	<0.2	626	<0.01	7	16.9	2340	<0.1	<0.02	1.2	6.8	<0.04	<0.5	42.0	<3
TQ0173	Beans	2	unwashed	93.33	5.3	0.6	25500	46800	<0.2	639	<0.01	10	17.0	2390	<0.1	<0.02	1.0	7.7	<0.04	<0.5	42.0	<3
TQ0173	Beans	3	unwashed	93.19	4.6	0.7	23300	46700	<0.2	590	<0.01	11	16.1	2290	<0.1	<0.02	1.1	7.6	<0.04	<0.5	39.9	<3
TQ0173	Beans	1	washed	93.33	5.3	0.6	22800	44200	<0.2	734	<0.01	11	16.3	2280	<0.1	<0.02	1.0	7.4	<0.04	<0.5	40.6	<3
TQ0173	Beans	2	washed	93.27	5.4	0.6	20200	38800	<0.2	759	<0.01	9	18.7	2320	<0.1	<0.02	0.6	7.3	<0.04	<0.5	41.9	<3
TQ0173	Beans	3	washed	93.04	5.5	0.6	26800	47500	<0.2	721	<0.01	18	14.5	2290	<0.1	<0.02	2.4	8.0	<0.04	<0.5	40.5	<3
TQ0174	Beans	1	unwashed	88.16	2.3	0.9	15800	45400	<0.2	806	<0.01	40	24.1	1620	<0.1	<0.02	1.1	5.6	<0.04	<0.5	27.8	<3
TQ0174	Beans	2	unwashed	88.49	2.2	0.9	13800	41100	<0.2	742	<0.01	33	23.0	1570	<0.1	<0.02	4.0	5.4	<0.04	<0.5	25.8	<3
TQ0174	Beans	3	unwashed	89.05	2.7	1.1	15700	37200	<0.2	678	<0.01	28	21.9	1820	<0.1	<0.02	1.0	5.6	<0.04	<0.5	30.8	<3
TQ0174	Beans	1	washed	87.92	2.6	1.0	18600	45400	<0.2	647	<0.01	30	17.8	1750	<0.1	<0.02	3.2	5.8	<0.04	<0.5	29.2	<3
TQ0174	Beans	2	washed	89.54	2.1	0.8	13200	40900	<0.2	576	<0.01	37	24.5	1610	<0.1	<0.02	1.9	4.8	<0.04	<0.5	26.3	<3
TQ0174	Beans	3	washed	88.39	2.6	0.8	17500	43000	<0.2	928	<0.01	36	20.2	1710	<0.1	<0.02	2.0	6.4	<0.04	<0.5	28.4	<3

Table A3-4. Analysis results (µg/g dry weight) for replicate tomato samples collected from garden sites, August 2002.

Site	Sample	Rep	Washed/Unwashed	Moisture (%)	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg
TQ0164	Tomatoes	1	unwashed	93.5	28.4	< 0.1	0.2	1.1	< 0.02	31	0.46	1330	0.3	< 0.1	15.3	74	0.4	2600	13.2	0.025
TQ0164	Tomatoes	2	unwashed	94.2	19.2	< 0.1	0.3	1.8	< 0.02	28	0.55	2700	0.2	< 0.1	16.4	58	0.3	2470	12.6	0.013
TQ0164	Tomatoes	3	unwashed	93.8	27.2	< 0.1	0.3	1.7	< 0.02	30	0.5	2320	0.3	< 0.1	16.7	69	0.4	2460	13.7	0.017
TQ0164	Tomatoes	1	washed	92.7	5.4	< 0.1	0.2	1.2	< 0.02	25	0.52	2140	< 0.1	< 0.1	13.5	45	< 0.1	2110	9.4	< 0.01
TQ0164	Tomatoes	2	washed	93.2	3.7	< 0.1	< 0.1	1	< 0.02	30	0.47	1900	0.2	< 0.1	14.3	44	< 0.1	2530	11.9	< 0.01
TQ0164	Tomatoes	3	washed	95.3	3.3	< 0.1	0.3	1.5	< 0.02	36	0.55	2580	0.3	< 0.1	20.3	54	< 0.1	3240	16.6	< 0.01
TQ0165	Tomatoes	1	unwashed	96.4	9.2	< 0.1	< 0.1	1.3	< 0.02	38	0.63	2050	0.2	< 0.1	17.4	57	0.2	3370	12.4	0.013
TQ0165	Tomatoes	2	unwashed	95.2	10.3	< 0.1	< 0.1	0.8	< 0.02	20	0.44	1300	0.2	< 0.1	9.6	37	0.2	1810	6.1	< 0.01
TQ0165	Tomatoes	3	unwashed	96.3	13.5	< 0.1	< 0.1	1.3	< 0.02	25	0.66	1930	0.5	< 0.1	15.6	48	0.3	2270	9.7	< 0.01
TQ0165	Tomatoes	1	washed	95.0	4.3	< 0.1	< 0.1	1.2	< 0.02	31	0.51	1930	0.2	< 0.1	12.8	45	0.2	2690	10.2	< 0.01
TQ0165	Tomatoes	2	washed	95.0	3.8	< 0.1	< 0.1	0.8	< 0.02	23	0.45	1500	0.1	< 0.1	9.2	28	< 0.1	2000	6.5	< 0.01
TQ0165	Tomatoes	3	washed	95.0	1.7	< 0.1	< 0.1	0.7	< 0.02	20	0.41	1360	0.1	< 0.1	9	23	< 0.1	1620	5.8	< 0.01
TQ0166	Tomatoes	1	unwashed	95.2	4.6	< 0.1	< 0.1	1.4	< 0.02	26	0.55	1760	0.2	< 0.1	17.4	60	0.1	2890	16.9	0.011
TQ0166	Tomatoes	2	unwashed	96.1	5.5	< 0.1	< 0.1	2	< 0.02	32	0.56	1910	0.2	< 0.1	17.9	63	0.2	3240	16.4	< 0.01
TQ0166	Tomatoes	3	unwashed	95.2	4.9	< 0.1	< 0.1	1.9	< 0.02	23	0.46	1880	0.2	< 0.1	12.9	48	0.1	2260	12.2	< 0.01
TQ0166	Tomatoes	1	washed	95.3	1.4	< 0.1	< 0.1	1.8	< 0.02	26	0.48	1710	0.2	< 0.1	12.1	42	< 0.1	2360	12.2	< 0.01
TQ0166	Tomatoes	2	washed	94.5	1.1	< 0.1	< 0.1	1.5	< 0.02	22	0.45	1410	0.2	< 0.1	10.5	30	< 0.1	1940	8.5	< 0.01
TQ0166	Tomatoes	3	washed	94.9	2	< 0.1	< 0.1	1.4	< 0.02	23	0.43	1460	0.2	< 0.1	12.7	40	< 0.1	2460	12.3	< 0.01
TQ0167	Tomatoes	1	unwashed	97.1	18.2	< 0.1	< 0.1	3.6	< 0.02	36	0.86	3380	0.2	< 0.1	21.5	65	0.2	3400	11.7	0.015
TQ0167	Tomatoes	2	unwashed	95.1	9.3	< 0.1	< 0.1	2	< 0.02	26	0.51	2010	0.2	< 0.1	14.9	72	< 0.1	2580	8.8	< 0.01
TQ0167	Tomatoes	3	unwashed	95.7	14.7	< 0.1	< 0.1	1.8	< 0.02	24	0.45	1860	0.2	< 0.1	12.1	46	0.2	2300	8.4	< 0.01
TQ0167	Tomatoes	1	washed	96.3	3.4	< 0.1	< 0.1	2.5	< 0.02	35	0.66	2390	0.2	< 0.1	17	40	< 0.1	3210	10.9	< 0.01
TQ0167	Tomatoes	2	washed	96.2	2.7	< 0.1	< 0.1	2.4	< 0.02	30	0.54	2270	0.1	< 0.1	14.8	33	< 0.1	2760	8.2	< 0.01
TQ0167	Tomatoes	3	washed	95.8	5.4	< 0.1	< 0.1	1.7	< 0.02	23	0.46	1780	0.2	< 0.1	12.6	36	< 0.1	2090	8	< 0.01
TQ0168	Tomatoes	1	unwashed	93.5	4.2	< 0.1	< 0.1	2.2	< 0.02	19	0.27	1630	0.1	< 0.1	14.8	49	< 0.1	2550	8.5	< 0.01
TQ0168	Tomatoes	2	unwashed	94.0	3.5	< 0.1	< 0.1	1.5	< 0.02	22	0.28	1250	0.2	< 0.1	16.2	51	< 0.1	2690	9.2	< 0.01
TQ0168	Tomatoes	3	unwashed	95.5	6.7	< 0.1	< 0.1	2.6	< 0.02	25	0.3	1890	0.2	< 0.1	19	81	< 0.1	3100	10.9	< 0.01
TQ0168	Tomatoes	1	washed	95.0	3.5	< 0.1	< 0.1	2.8	< 0.02	25	0.33	1950	0.2	< 0.1	17.6	52	1	3230	10.8	< 0.01
TQ0168	Tomatoes	2	washed	95.0	3.1	< 0.1	< 0.1	2.3	< 0.02	29	0.36	1540	0.2	< 0.1	19.9	64	< 0.1	3160	11	< 0.01
TQ0168	Tomatoes	3	washed	93.9	2.5	< 0.1	< 0.1	2.1	< 0.02	21	0.24	1550	0.2	< 0.1	15.4	61	< 0.1	2720	10.2	< 0.01
TQ0169	Tomatoes	1	washed	92.5	4.6	< 0.1	< 0.1	1	< 0.02	17	0.26	1370	0.2	< 0.1	6.2	48	< 0.1	2000	10.5	< 0.01
TQ0170	Tomatoes	1	unwashed	95.8	14.9	< 0.1	< 0.1	2.6	< 0.02	26	0.76	2460	0.2	< 0.1	15.7	62	0.1	2680	7.2	< 0.01
TQ0170	Tomatoes	2	unwashed	95.8	33.1	< 0.1	< 0.1	2.3	< 0.02	26	0.54	2110	0.2	< 0.1	14.4	81	0.2	2450	8.3	< 0.01
TQ0170	Tomatoes	3	unwashed	95.1	44.8	< 0.1	< 0.1	2.2	< 0.02	28	0.45	1870	0.3	< 0.1	14.3	100	0.2	2470	9.2	0.012
TQ0170	Tomatoes	1	washed	96.3	5	< 0.1	< 0.1	2.9	< 0.02	30	0.81	2680	0.2	< 0.1	16.3	54	< 0.1	3070	8	< 0.01
TQ0170	Tomatoes	2	washed	96.3	5.6	< 0.1	< 0.1	2.5	< 0.02	27	0.51	2210	0.2	< 0.1	14	53	< 0.1	2610	8.4	< 0.01
TQ0170	Tomatoes	3	washed	94.5	8.3	< 0.1	< 0.1	1.9	< 0.02	27	0.45	1970	0.2	< 0.1	13.5	55	< 0.1	2470	8.8	< 0.01
TQ0171	Tomatoes	1	unwashed	97.1	58.4	< 0.1	< 0.1	2.9	< 0.02	32	0.54	2990	0.3	0.1	23.4	156	0.1	3930	15.2	< 0.01
TQ0171	Tomatoes	2	unwashed	97.0	25.9	< 0.1	< 0.1	2.4	< 0.02	28	0.58	2760	0.2	0.1	20.4	100	< 0.1	3270	11.6	< 0.01
TQ0171	Tomatoes	3	unwashed	96.0	25	< 0.1	< 0.1	1.6	< 0.02	26	0.48	2140	0.3	< 0.1	12.8	71	< 0.1	2670	8.7	< 0.01
TQ0171	Tomatoes	1	washed	96.8	16.8	< 0.1	< 0.1	2.5	< 0.02	28	0.51	2820	0.2	0.1	21.3	96	< 0.1	3350	12.7	< 0.01
TQ0171	Tomatoes	2	washed	96.9	4.8	< 0.1	< 0.1	2.2	< 0.02	29	0.51	2750	0.2	< 0.1	20.3	65	< 0.1	3330	11	< 0.01
TQ0171	Tomatoes	3	washed	96.5	3.6	< 0.1	< 0.1	1.7	< 0.02	25	0.49	2200	0.2	< 0.1	13.7	45	< 0.1	2660	8	0.012
TQ0172	Tomatoes	1	washed	94.0	9.6	< 0.1	< 0.1	1.1	< 0.02	23	0.22	1380	0.2	< 0.1	8.9	49	< 0.1	2280	7.5	< 0.01
TQ0172	Tomatoes	2	washed	93.7	4.6	< 0.1	< 0.1	1	< 0.02	17	0.21	1110	0.1	< 0.1	8.8	35	< 0.1	1790	6	< 0.01
TQ0172	Tomatoes	3	washed	93.4	5.3	< 0.1	< 0.1	0.8	< 0.02	17	0.21	1080	0.2	< 0.1	9.2	37	< 0.1	1900	6.8	< 0.01
TQ0173	Tomatoes	1	unwashed	97.2	8.8	< 0.1	< 0.1	1	< 0.02	25	0.12	3440	0.2	< 0.1	9.4	59	< 0.1	3040	11	< 0.01
TQ0173	Tomatoes	2	unwashed	95.8	6	< 0.1	< 0.1	0.8	< 0.02	25	0.12	3320	0.2	< 0.1	10.4	56	< 0.1	3280	11.7	< 0.01
TQ0173	Tomatoes	3	unwashed	95.7	12.2	< 0.1	< 0.1	1.1	< 0.02	23	0.13	3920	0.1	< 0.1	9.5	72	< 0.1	3360	11.9	< 0.01
TQ0173	Tomatoes	1	washed	96.6	3.9	< 0.1	< 0.1	1	< 0.02	25	0.14	3410	0.2	< 0.1	11.2	54	< 0.1	3280	11.7	< 0.01
TQ0173	Tomatoes	2	washed	96.1	2.8	< 0.1	< 0.1	0.8	< 0.02	24	0.12	3500	< 0.1	< 0.1	10.6	51	< 0.1	3490	11.5	< 0.01
TQ0173	Tomatoes	3	washed	96.4	3.4	< 0.1	< 0.1	0.8	< 0.02	23	0.09	3220	0.1	< 0.1	8.3	58	< 0.1	3060	10.7	< 0.01
TQ0174	Tomatoes	1	unwashed	94.2	10.8	< 0.1	< 0.1	0.8	< 0.02	26	0.15	1550	0.2	< 0.1	8.3	67	< 0.1	2630	12	< 0.01
TQ0174	Tomatoes	2	unwashed	93.1	8.3	< 0.1	< 0.1	0.6	< 0.02	26	0.16	1490	0.2	< 0.1	6.9	60	< 0.1	2640	12	< 0.01
TQ0174	Tomatoes	3	unwashed	93.2	11.1	< 0.1	< 0.1	0.9	< 0.02	23	0.16	1310	0.2	< 0.1	6.6	65	< 0.1	2350	10.4	< 0.01
TQ0174	Tomatoes	1	washed	94.9	21.5	< 0.1	< 0.1	0.8	< 0.02	26	0.18	1160	0.4	< 0.1	10.3	82	< 0.1	2770	14.4	< 0.01
TQ0174	Tomatoes	2	washed	94.6	3.5	< 0.1	< 0.1	0.5	< 0.02	26	0.18	1150	0.2	< 0.1	8.6	60	< 0.1	2710	12.8	< 0.01
TQ0174	Tomatoes	3	washed	95.0	8.5	< 0.1	< 0.1	1.1	< 0.02	34	0.23	1830	0.2	< 0.1	10.3	90	< 0.1	3720	16.2	< 0.01

Table A3-4 continued.

Site	Sample	Rep	Washed/Unwashed	Moisture (%)	Mo	Ni	PO4	K	Se	SiO2	Ag	Na	Sr	S	Te	Tl	Sn	Ti	U	V	Zn	Zr
TQ0164	Tomatoes	1	unwashed	93.5	1.5	0.2	15000	50000	8.3	145	< 0.01	613	2.93	2690	< 0.1	< 0.02	< 0.1	3.5	< 0.04	< 0.5	64.1	< 3
TQ0164	Tomatoes	2	unwashed	94.2	1.6	0.2	12000	49200	8.5	128	< 0.01	876	6.38	2930	< 0.1	< 0.02	< 0.1	2.6	< 0.04	< 0.5	68.5	< 3
TQ0164	Tomatoes	3	unwashed	93.8	1.4	0.3	12100	46700	8	151	< 0.01	894	5.26	2780	< 0.1	< 0.02	< 0.1	3	< 0.04	< 0.5	63.7	< 3
TQ0164	Tomatoes	1	washed	92.7	1.3	0.2	11300	36300	5.2	122	< 0.01	434	4.99	2440	< 0.1	< 0.02	< 0.1	1.8	< 0.04	< 0.5	52.2	< 3
TQ0164	Tomatoes	2	washed	93.2	1.3	0.2	14100	48800	7	136	< 0.01	563	4.35	2490	< 0.1	< 0.02	< 0.1	2.2	< 0.04	< 0.5	60	< 3
TQ0164	Tomatoes	3	washed	95.3	1.8	0.3	17100	69300	10.6	221	< 0.01	985	6.18	3300	< 0.1	< 0.02	< 0.1	2.5	< 0.04	< 0.5	77.9	< 3
TQ0165	Tomatoes	1	unwashed	96.4	2.1	0.2	23600	59000	< 0.2	172	< 0.01	172	3.1	2890	< 0.1	< 0.02	< 0.1	3.9	< 0.04	< 0.5	47	< 3
TQ0165	Tomatoes	2	unwashed	95.2	1.5	0.3	12500	41300	< 0.2	112	< 0.01	116	2.24	2110	< 0.1	< 0.02	< 0.1	2.3	< 0.04	< 0.5	27.3	< 3
TQ0165	Tomatoes	3	unwashed	96.3	2.2	0.2	16100	53900	< 0.2	143	< 0.01	169	3.37	2700	< 0.1	< 0.02	< 0.1	2.9	< 0.04	< 0.5	34.7	< 3
TQ0165	Tomatoes	1	washed	95.0	1.7	0.2	18500	44200	< 0.2	190	< 0.01	143	3	2220	< 0.1	< 0.02	< 0.1	2.7	< 0.04	< 0.5	34.4	< 3
TQ0165	Tomatoes	2	washed	95.0	1.7	0.2	14000	48100	< 0.2	110	< 0.01	128	2.43	2110	< 0.1	< 0.02	< 0.1	2.1	< 0.04	< 0.5	29	< 3
TQ0165	Tomatoes	3	washed	95.0	1.5	0.2	11600	39500	< 0.2	100	< 0.01	111	2.41	2120	< 0.1	< 0.02	< 0.1	1.6	< 0.04	< 0.5	25	< 3
TQ0166	Tomatoes	1	unwashed	95.2	1	0.2	12700	62200	< 0.2	110	< 0.01	423	3.32	2620	< 0.1	< 0.02	< 0.1	1.9	< 0.04	< 0.5	58.2	< 3
TQ0166	Tomatoes	2	unwashed	96.1	1.1	0.2	15100	56200	< 0.2	145	< 0.01	397	4.29	2500	< 0.1	< 0.02	< 0.1	2.2	< 0.04	< 0.5	58.9	< 3
TQ0166	Tomatoes	3	unwashed	95.2	0.7	0.2	10200	38600	< 0.2	158	< 0.01	310	4.35	1460	< 0.1	< 0.02	< 0.1	1.6	< 0.04	< 0.5	44.9	< 3
TQ0166	Tomatoes	1	washed	95.3	0.9	0.2	10600	45400	< 0.2	122	< 0.01	332	4.16	1950	< 0.1	< 0.02	< 0.1	1.5	< 0.04	< 0.5	44.2	< 3
TQ0166	Tomatoes	2	washed	94.5	0.7	0.2	8920	42700	< 0.2	104	< 0.01	272	3.52	1760	< 0.1	< 0.02	< 0.1	1.2	< 0.04	< 0.5	38.1	< 3
TQ0166	Tomatoes	3	washed	94.9	0.8	0.2	10700	60900	< 0.2	148	< 0.01	312	3.42	1460	< 0.1	< 0.02	< 0.1	1.5	< 0.04	< 0.5	44.2	< 3
TQ0167	Tomatoes	1	unwashed	97.1	1.7	0.2	26400	74400	< 0.2	134	< 0.01	336	7.38	3470	< 0.1	< 0.02	< 0.1	4.5	< 0.04	< 0.5	47.3	< 3
TQ0167	Tomatoes	2	unwashed	95.1	1.1	1.4	18200	71600	< 0.2	127	< 0.01	262	4.27	1640	< 0.1	< 0.02	< 0.1	2.9	< 0.04	< 0.5	31.3	< 3
TQ0167	Tomatoes	3	unwashed	95.7	1.1	0.1	14900	50500	< 0.2	125	< 0.01	291	4.06	2100	< 0.1	< 0.02	< 0.1	2.9	< 0.04	< 0.5	27.5	< 3
TQ0167	Tomatoes	1	washed	96.3	1.4	0.1	22800	61400	< 0.2	153	< 0.01	279	5.12	3000	< 0.1	< 0.02	< 0.1	3.1	< 0.04	< 0.5	36.5	< 3
TQ0167	Tomatoes	2	washed	96.2	1.2	0.1	20000	58700	< 0.2	116	< 0.01	285	5.31	2260	< 0.1	< 0.02	< 0.1	2.8	< 0.04	< 0.5	32.9	< 3
TQ0167	Tomatoes	3	washed	95.8	1.3	0.2	16000	43500	< 0.2	140	< 0.01	256	3.92	2030	< 0.1	< 0.02	< 0.1	2.4	< 0.04	< 0.5	29.5	< 3
TQ0168	Tomatoes	1	unwashed	93.5	0.8	0.1	12500	56700	< 0.2	63	< 0.01	187	3.45	2180	< 0.1	< 0.02	< 0.1	1.9	< 0.04	< 0.5	27.9	< 3
TQ0168	Tomatoes	2	unwashed	94.0	1	0.2	12900	46900	< 0.2	81	< 0.01	177	2.22	2820	< 0.1	< 0.02	< 0.1	1.9	< 0.04	< 0.5	30.6	< 3
TQ0168	Tomatoes	3	unwashed	95.5	1.2	0.2	13100	55200	< 0.2	131	< 0.01	280	3.8	2940	< 0.1	< 0.02	< 0.1	2.1	< 0.04	< 0.5	34.5	< 3
TQ0168	Tomatoes	1	washed	95.0	1	0.1	14600	56300	< 0.2	114	< 0.01	270	3.91	2830	< 0.1	< 0.02	< 0.1	2	< 0.04	< 0.5	31.6	< 3
TQ0168	Tomatoes	2	washed	95.0	1.2	0.2	15900	54900	< 0.2	92	< 0.01	215	2.97	3100	< 0.1	< 0.02	< 0.1	2.2	< 0.04	< 0.5	35.9	< 3
TQ0168	Tomatoes	3	washed	93.9	1	0.2	11600	57900	< 0.2	101	< 0.01	193	3.18	2480	< 0.1	< 0.02	< 0.1	1.7	< 0.04	< 0.5	28.1	< 3
TQ0169	Tomatoes	1	washed	92.5	0.9	< 0.1	11900	44900	< 0.2	101	< 0.01	141	1.66	1730	< 0.1	< 0.02	< 0.1	1.8	< 0.04	< 0.5	24.9	< 3
TQ0170	Tomatoes	1	unwashed	95.8	0.8	0.2	13300	65700	< 0.2	133	< 0.01	303	5.36	2410	< 0.1	< 0.02	< 0.1	2.7	< 0.04	< 0.5	40.9	< 3
TQ0170	Tomatoes	2	unwashed	95.8	0.8	0.3	12100	63800	< 0.2	120	< 0.01	220	4.02	2260	< 0.1	< 0.02	< 0.1	3.7	< 0.04	< 0.5	39.7	< 3
TQ0170	Tomatoes	3	unwashed	95.1	0.7	0.2	16000	62100	< 0.2	119	< 0.01	198	3.52	2190	< 0.1	< 0.02	< 0.1	4.8	< 0.04	< 0.5	36.4	< 3
TQ0170	Tomatoes	1	washed	96.3	1	0.2	15200	61600	< 0.2	138	< 0.01	355	5.85	2990	< 0.1	< 0.02	< 0.1	2.2	< 0.04	< 0.5	41.8	< 3
TQ0170	Tomatoes	2	washed	96.3	0.8	0.2	13300	52800	< 0.2	139	< 0.01	241	4.37	2860	< 0.1	< 0.02	< 0.1	2.1	< 0.04	< 0.5	38.3	< 3
TQ0170	Tomatoes	3	washed	94.5	0.8	0.2	15400	46600	< 0.2	118	< 0.01	165	3.45	2410	< 0.1	< 0.02	< 0.1	2.5	< 0.04	< 0.5	34.8	< 3
TQ0171	Tomatoes	1	unwashed	97.1	1.4	0.3	13800	61600	< 0.2	148	< 0.01	341	4.97	2930	< 0.1	< 0.02	< 0.1	5.7	< 0.04	0.5	48.4	< 3
TQ0171	Tomatoes	2	unwashed	97.0	1.2	0.2	13200	57400	< 0.2	136	< 0.01	313	4.85	2870	< 0.1	< 0.02	< 0.1	3.4	< 0.04	< 0.5	41.9	< 3
TQ0171	Tomatoes	3	unwashed	96.0	0.9	0.2	10100	39600	< 0.2	131	< 0.01	227	3.23	2100	< 0.1	< 0.02	< 0.1	2.9	< 0.04	< 0.5	25	< 3
TQ0171	Tomatoes	1	washed	96.8	1.3	0.2	12000	55300	< 0.2	105	< 0.01	313	4.67	2920	< 0.1	< 0.02	< 0.1	2.7	< 0.04	< 0.5	43.8	< 3
TQ0171	Tomatoes	2	washed	96.9	1.1	0.2	12000	50900	< 0.2	170	< 0.01	315	4.69	2560	< 0.1	< 0.02	< 0.1	1.9	< 0.04	< 0.5	35	< 3
TQ0171	Tomatoes	3	washed	96.5	0.9	0.2	11000	46100	< 0.2	136	< 0.01	225	3.65	2420	< 0.1	< 0.02	< 0.1	1.7	< 0.04	< 0.5	28.8	< 3
TQ0172	Tomatoes	1	washed	94.0	1.1	0.2	16900	55000	< 0.2	126	< 0.01	107	1.95	1830	< 0.1	< 0.02	< 0.1	2.7	< 0.04	< 0.5	19.9	< 3
TQ0172	Tomatoes	2	washed	93.7	0.9	0.1	14200	48900	< 0.2	97	< 0.01	87	1.92	1680	< 0.1	< 0.02	< 0.1	2.1	< 0.04	< 0.5	19.4	< 3
TQ0172	Tomatoes	3	washed	93.4	1	0.1	13600	45600	< 0.2	103	< 0.01	88	1.67	1580	< 0.1	< 0.02	< 0.1	2	< 0.04	< 0.5	19.4	< 3
TQ0173	Tomatoes	1	unwashed	97.2	1.6	0.1	18100	62900	< 0.2	140	< 0.01	626	5.56	2260	< 0.1	< 0.02	< 0.1	2.8	< 0.04	< 0.5	26.3	< 3
TQ0173	Tomatoes	2	unwashed	95.8	1.7	0.1	18500	62700	< 0.2	148	< 0.01	1280	5.11	2200	< 0.1	< 0.02	< 0.1	2.7	< 0.04	< 0.5	33.6	< 3
TQ0173	Tomatoes	3	unwashed	95.7	1.4	0.1	18600	49100	< 0.2	104	< 0.01	903	6.5	2650	< 0.1	< 0.02	< 0.1	3.1	< 0.04	< 0.5	31.7	< 3
TQ0173	Tomatoes	1	washed	96.6	1.7	0.1	19200	65800	< 0.2	111	< 0.01	625	5.73	2750	< 0.1	< 0.02	< 0.1	2.7	< 0.04	< 0.5	30.5	< 3
TQ0173	Tomatoes	2	washed	96.1	1.6	0.1	19000	63800	< 0.2	96	< 0.01	1110	5.63	2520	< 0.1	< 0.02	< 0.1	2.6	< 0.04	< 0.5	30.8	< 3
TQ0173	Tomatoes	3	washed	96.4	1.3	0.1	17200	58300	< 0.2	139	< 0.01	846	5.08	1840	< 0.1	< 0.02	< 0.1	2.4	< 0.04	< 0.5	27.8	< 3
TQ0174	Tomatoes	1	unwashed	94.2	1.1	0.3	12800	54800	< 0.2	120	< 0.01	344	3.17	2350	< 0.1	< 0.02	< 0.1	1.8	< 0.04	< 0.5	25.3	< 3
TQ0174	Tomatoes	2	unwashed	93.1	1.3	0.3	11900	46400	< 0.2	173	< 0.01	361	2.97	2260	< 0.1	< 0.02	< 0.1	1.9	< 0.04	< 0.5	25.4	< 3
TQ0174	Tomatoes	3	unwashed	93.2	1.1	0.2	11300	64100	< 0.2	143	< 0.01	289	2.55	1810	< 0.1	< 0.02	< 0.1	1.8	< 0.04	< 0.5	24.4	< 3
TQ0174	Tomatoes	1	washed	94.9	1.4	0.6	15000	60400	< 0.2	68	< 0.01	355	2.64	2780	< 0.1	< 0.02	< 0.1	2.6	< 0.04	< 0.5	33.2	< 3
TQ0174	Tomatoes	2	washed	94.6	1.3	0.3	12700	58300	< 0.2	139	< 0.01	361	2.5	2830	< 0.1	< 0.02	< 0.1	1.8	< 0.04	< 0.5	29.8	< 3
TQ0174	Tomatoes	3	washed	95.0	1.7	0.4	18000	61600	< 0.2	142	< 0.01	473	3.55	2950	< 0.1	< 0.02	< 0.1	2.6	< 0.04	< 0.5	36.4	< 3

Table A3-5. Analysis results (µg/g dry weight) for replicate lettuce samples collected from garden sites, August 2002.

Site	Sample	Rep	Washed/Unwashed	Moisture (%)	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg
TQ0164	Lettuce	1	unwashed	89.02	1010	0.5	9.3	28.8	0.04	32	9.17	14600	7.2	1.0	182	1830	28.5	4840	52.5	1.290
TQ0164	Lettuce	2	unwashed	90.66	990	0.4	10.3	28	0.03	37	10.80	17600	8.3	1.1	195	1910	28.6	5330	53.6	1.360
TQ0164	Lettuce	3	unwashed	89.57	924	0.8	9.4	25.5	0.03	30	9.76	15100	5.4	1.0	181	1710	26.6	4640	49.1	1.360
TQ0164	Lettuce	1	washed	89.66	158	<0.1	2.6	8.7	<0.02	28	8.99	13700	1.1	0.2	50.6	392	8.3	4640	29.7	0.502
TQ0164	Lettuce	2	washed	90.72	141	<0.1	2.3	8.2	<0.02	27	7.91	12300	1.4	0.2	46.4	352	6.3	3750	25.3	0.196
TQ0164	Lettuce	3	washed	91.05	148	<0.1	2.7	8.3	<0.02	26	7.40	12700	1.5	0.2	50.6	399	6.4	3900	26.1	0.233
TQ0165	Lettuce	1	unwashed	95.83	1250	<0.1	6.4	42.1	0.04	46	9.89	24200	7.3	1.3	181	2080	37.4	6540	45.5	0.347
TQ0165	Lettuce	2	unwashed	94.74	611	<0.1	4.7	23.1	<0.02	52	8.31	21000	5.0	0.8	131	1190	19.9	5060	26.1	0.200
TQ0165	Lettuce	3	unwashed	94.69	174	<0.1	2.5	11	<0.02	50	6.04	20300	1.1	0.3	70.4	511	10.6	4920	16.6	0.166
TQ0165	Lettuce	1	washed	95.54	228	<0.1	3.1	14.7	<0.02	58	8.70	21800	1.7	0.4	85.5	628	11.6	5060	18.4	0.126
TQ0165	Lettuce	2	washed	97.35	175	<0.1	2.3	18.8	<0.02	70	8.21	28100	1.4	0.5	59.4	510	7.2	5980	22.7	0.161
TQ0165	Lettuce	3	washed	95.56	133	<0.1	1.9	12.5	<0.02	45	6.65	20400	1.7	0.2	45.0	382	6.4	4760	13.8	0.087
TQ0166	Lettuce	1	unwashed	96.65	110	<0.1	1.4	15.8	<0.02	50	3.38	14600	1.0	0.2	40.7	308	3.5	5520	17.3	0.086
TQ0166	Lettuce	2	unwashed	95.48	314	<0.1	4.1	20.2	<0.02	44	7.01	19800	2.0	0.5	120	995	14.7	6220	31.1	0.272
TQ0166	Lettuce	3	unwashed	94.46	987	<0.1	8.2	29.4	0.03	47	7.59	21100	6.1	1.2	181	2050	21.1	6860	58.0	0.234
TQ0166	Lettuce	1	washed	94.80	811	<0.1	5.7	27.3	<0.02	62	5.87	21300	4.2	0.9	146	1440	15.1	5900	54.3	0.452
TQ0166	Lettuce	2	washed	95.74	107	<0.1	1.5	16.6	<0.02	54	5.33	18000	1.4	0.2	54.6	357	5.2	6730	25.0	0.099
TQ0166	Lettuce	3	washed	96.47	219	<0.1	3.7	24.2	<0.02	74	6.76	27400	1.5	0.4	90.6	625	8.5	7890	52.4	0.199
TQ0167	Lettuce	1	unwashed	95.15	735	0.4	7.3	31.8	0.02	35	7.57	22200	3.9	1.0	143	1710	43.4	4410	46.5	0.202
TQ0167	Lettuce	2	unwashed	96.42	792	<0.1	6.3	32.5	0.03	40	5.89	21600	5.2	1.0	123	1760	17.2	4970	51.5	0.139
TQ0167	Lettuce	3	unwashed	97.26	686	<0.1	8.7	35.1	0.02	42	9.47	29100	5.1	1.2	167	1760	24.2	5060	58.7	0.292
TQ0167	Lettuce	1	washed	95.88	126	<0.1	2.1	20.6	<0.02	38	5.75	21500	0.7	0.2	44.9	474	6.6	4260	19.3	0.068
TQ0167	Lettuce	2	washed	97.70	122	<0.1	2.3	23.9	<0.02	39	4.93	20300	0.9	0.3	48.4	401	6.1	4370	18.6	0.105
TQ0167	Lettuce	3	washed	96.71	208	<0.1	3.9	29	<0.02	38	6.44	25100	1.6	0.5	83.7	729	10.6	4370	20.4	0.072
TQ0168	Lettuce	1	unwashed	95.39	860	<0.1	3.5	31.4	0.03	34	4.78	14000	3.9	0.8	127	1580	25.1	5940	40.8	0.157
TQ0168	Lettuce	2	unwashed	95.62	558	<0.1	4.2	27.2	0.02	38	4.85	14500	3.0	0.7	130	1220	26.4	5520	32.0	0.141
TQ0168	Lettuce	3	unwashed	96.12	902	<0.1	4.6	34.1	0.07	42	5.79	17300	3.6	1.0	158.0	1830	33.2	6920	48.1	0.160
TQ0168	Lettuce	1	washed	95.51	280	<0.1	1.9	29.8	<0.02	37	4.33	15400	1.5	0.3	57.9	615	11.4	5910	21.9	0.078
TQ0168	Lettuce	2	washed	95.98	258	<0.1	1.5	23.5	<0.02	33	4.03	14800	1.2	0.3	53.2	560	9.5	5270	22.9	0.080
TQ0168	Lettuce	3	washed	95.56	247	<0.1	1.9	29.4	<0.02	35	3.94	15800	1.0	0.3	54.8	550	10.6	6190	20.8	0.135
TQ0169	Lettuce	1	unwashed	91.43	859	<0.1	3.6	22.7	<0.02	30	6.51	17800	10.5	0.8	89.2	1460	13.2	5280	68.8	0.109
TQ0169	Lettuce	2	unwashed	92.17	470	<0.1	3	17.3	<0.02	30	5.48	15500	3.8	0.4	74.6	889	10.2	5120	53.1	0.151
TQ0169	Lettuce	3	unwashed	91.85	592	<0.1	3.9	20.2	<0.02	34	7.21	20000	3.5	0.6	91.7	1080	13.6	5460	66.4	0.142
TQ0169	Lettuce	1	washed	92.92	68.3	<0.1	0.9	12.9	<0.02	28	5.26	16400	0.7	0.1	28.3	216	4.1	4880	50.8	0.028
TQ0169	Lettuce	2	washed	92.84	118	<0.1	1.4	13.2	<0.02	29	5.30	16500	0.8	0.2	31.7	302	4.8	4710	51.3	0.057
TQ0169	Lettuce	3	washed	92.59	210	<0.1	2.2	15.6	<0.02	33	6.10	19200	1.8	0.3	48.0	466	7.2	5800	55.9	0.070
TQ0170	Lettuce	1	unwashed	93.10	1280	<0.1	3	25	0.05	26	3.32	15300	3.3	0.8	99.7	1750	11.1	6680	36.3	0.125
TQ0170	Lettuce	2	unwashed	93.72	1640	<0.1	3.4	26.9	0.06	36	3.34	15200	4.6	1.0	101	2190	13.0	6450	54.2	0.143
TQ0170	Lettuce	3	unwashed	92.75	1170	<0.1	2.4	19.6	0.04	22	2.28	10800	3.4	0.6	73.4	1490	8.2	5580	34.7	0.100
TQ0170	Lettuce	1	washed	94.70	350	<0.1	1.3	17.5	<0.02	31	2.99	16100	2.5	0.3	40.1	647	5.1	5720	29.8	0.073
TQ0170	Lettuce	2	washed	93.82	268	<0.1	1.4	14.1	<0.02	27	2.67	13700	1.6	0.2	44.6	511	4.9	5420	28.9	0.077
TQ0170	Lettuce	3	washed	94.60	289	<0.1	1	20	<0.02	31	2.92	18500	1.0	0.2	36.3	491	3.6	7580	31.1	0.076
TQ0171	Lettuce	1	washed	93.82	210	<0.1	0.9	11.4	<0.02	30	3.87	12100	0.6	0.1	33.7	357	5.2	7330	14.8	0.059
TQ0171	Lettuce	2	washed	93.38	221	<0.1	0.9	12	<0.02	28	3.86	11900	0.6	0.1	29.9	331	4.8	7300	13.1	0.058
TQ0171	Lettuce	3	washed	93.77	185	<0.1	0.7	12.1	<0.02	28	3.29	12100	0.6	0.1	30.0	325	4.3	7470	11.8	0.057
TQ0172	Lettuce	1	unwashed	92.04	1980	<0.1	1.4	32.4	0.08	26	2.37	15200	5.6	1.0	32.8	2310	5.0	5190	44.3	0.255
TQ0172	Lettuce	2	unwashed	92.17	998	<0.1	1.1	26.9	0.04	30	2.32	17800	2.9	0.5	32.0	1250	4.8	5460	27.7	0.064
TQ0172	Lettuce	3	unwashed	92.88	1720	<0.1	1.2	29.1	0.07	27	2.18	13900	4.9	0.8	31.0	1950	4.3	5140	42.0	0.072
TQ0172	Lettuce	1	washed	93.26	403	<0.1	0.4	22.9	<0.02	29	2.08	17900	1.2	0.2	14.8	552	1.8	5130	21.7	0.031
TQ0172	Lettuce	2	washed	93.08	590	<0.1	0.6	21.4	<0.02	37	2.40	19100	1.5	0.3	18.2	726	2.9	5640	24.5	0.060
TQ0172	Lettuce	3	washed	93.69	414	<0.1	0.5	21.9	<0.02	32	2.40	19100	1.1	0.2	15.3	518	2.0	5670	25.9	0.037
TQ0173	Lettuce	1	unwashed	96.33	592	<0.1	0.3	14	<0.02	39	0.49	19100	2.7	0.4	11.7	968	2.2	10600	33.3	0.041
TQ0173	Lettuce	2	unwashed	95.53	285	<0.1	0.2	8.2	<0.02	30	0.38	11700	1.7	0.2	9.2	524	1.2	6950	20.4	0.035
TQ0173	Lettuce	3	unwashed	95.78	261	<0.1	0.2	9.2	<0.02	33	0.37	13300	1.8	0.2	8.2	469	1.1	7810	20.1	0.032
TQ0173	Lettuce	1	washed	95.81	614	<0.1	0.1	8.2	<0.02	37	0.37	15800	0.2	<0.1	9.6	186	0.5	8140	17.7	0.038
TQ0173	Lettuce	2	washed	95.61	485	<0.1	0.1	8.7	<0.02	48	0.40	15700	0.3	<0.1	10.5	197	0.6	9330	24.6	0.042
TQ0173	Lettuce	3	washed	95.67	572	<0.1	0.2	7.2	<0.02	31	0.57	12700	0.4	<0.1	15.6	304	0.9	6550	24.7	0.047
TQ0174	Lettuce	1	unwashed	92.49	580	<0.1	0.4	20.5	0.04	31	0.51	17900	1.5	0.3	10.1	881	0.5	7960	44.2	0.031
TQ0174	Lettuce	2	unwashed	92.06	439	<0.1	0.3	16.4	0.03	25	0.41	14300	1.3	0.2	9.5	633	0.4	6540	33.9	0.025
TQ0174	Lettuce	3	unwashed	91.88	369	<0.1	0.3	15.3	0.02	21	0.42	13100	1.0	0.2	10.1	655	0.5	5680	32.8	0.024
TQ0174	Lettuce	1	washed	93.10	54	<0.1	<0.1	5.7	<0.02	26	0.37	10100	0.2	<0.1	10.1	99	0.1	5460	24.7	0.028
TQ0174	Lettuce	2	washed	93.08	74.7	<0.1	<0.1	8.3	<0.02	27	0.48	13400	0.7	<0.1	10.7	160	0.2	6570	27.7	0.033
TQ0174	Lettuce	3	washed	92.99	76	<0.1	<0.1	9.1	<0.02	26	0.45	13900	0.2	<0.1	11.5	182	0.1	6320	29.9	0.032

Table A3-5 continued.

Site	Sample	Rep	Washed/Unwashed	Moisture (%)	Mo	Ni	PO4	K	Sr	SiO2	Ag	Na	Sr	S	Te	Tl	Sn	Ti	U	V	Zn	Zr
TQ0164	Lettuce	1	unwashed	89 02	1 0	7 4	13000	40800	7 4	427	0 16	2960	42 2	4540	< 0 1	0 05	0 2	48 4	0 07	2 3	598	< 3
TQ0164	Lettuce	2	unwashed	90 06	1 0	7 7	13300	40400	8 6	467	0 17	3010	47 9	5370	< 0 1	0 05	< 0 1	45 3	0 07	2 3	678	< 3
TQ0164	Lettuce	3	unwashed	89 57	0 9	2 7	12800	42200	8 5	284	0 15	2490	44 1	5100	< 0 1	0 04	< 0 1	39 8	0 06	2 1	602	< 3
TQ0164	Lettuce	1	washed	89 66	0 6	1 9	13000	38600	8 2	209	< 0 01	3650	38 3	4490	< 0 1	< 0 02	< 0 1	12 9	< 0 04	< 0 5	314	< 3
TQ0164	Lettuce	2	washed	90 72	0 6	7 6	12800	39600	6 7	230	< 0 01	2450	34 5	4000	< 0 1	< 0 02	< 0 1	11 3	< 0 04	< 0 5	296	< 3
TQ0164	Lettuce	3	washed	91 05	0 6	2 6	13400	36300	7 1	271	< 0 01	2280	35 8	3990	< 0 1	< 0 02	< 0 1	11 8	< 0 04	< 0 5	290	< 3
TQ0165	Lettuce	1	unwashed	95 83	1 9	4 1	27100	52800	0 9	652	0 33	2000	54 4	5660	< 0 1	0 06	< 0 1	46 5	0 09	3 0	484	< 3
TQ0165	Lettuce	2	unwashed	94 74	1 8	3 4	29100	31400	0 7	427	0 10	850	42 2	5170	< 0 1	<0 02	< 0 1	26 2	< 0 04	1 4	343	< 3
TQ0165	Lettuce	3	unwashed	94 60	1 5	0 9	25600	39100	0 4	348	0 05	1690	41 0	4490	< 0 1	0 02	< 0 1	16 8	< 0 04	< 0 5	225	< 3
TQ0165	Lettuce	1	washed	95 54	1 7	1 1	32400	63900	0 5	337	< 0 01	865	41 2	5070	< 0 1	< 0 02	< 0 1	16 1	< 0 04	0 7	568	< 3
TQ0165	Lettuce	2	washed	97 35	1 5	2 1	46300	37300	0 7	345	< 0 01	1180	55 7	5570	< 0 1	0 02	< 0 1	21 8	< 0 04	0 6	280	< 3
TQ0165	Lettuce	3	washed	95 56	1 3	3 8	31100	58100	0 4	370	0 02	869	41 7	4810	< 0 1	< 0 02	0 9	12 1	< 0 04	< 0 5	187	< 3
TQ0166	Lettuce	1	unwashed	96 65	0 4	2 2	22800	57200	<0 2	286	< 0 01	1860	43 5	3730	< 0 1	< 0 02	< 0 1	10 9	< 04	< 0 5	204	< 3
TQ0166	Lettuce	2	unwashed	95 48	0 9	1 2	9320	63400	0 6	831	0 09	2070	56 6	4290	< 0 1	< 0 02	< 0 1	26 3	0 08	1 0	343	< 3
TQ0166	Lettuce	3	unwashed	94 46	0 9	0 7	13100	53700	0 7	325	0 12	2910	62 9	4560	< 0 1	< 0 02	< 0 1	39 9	0 24	2 6	508	< 3
TQ0166	Lettuce	1	washed	94 80	0 7	3 8	22400	48900	0 7	426	0 10	1540	64 2	4150	< 0 1	< 0 02	< 0 1	36 5	0 16	2 0	414	< 3
TQ0166	Lettuce	2	washed	95 74	0 5	4 8	25800	57300	<0 2	328	< 0 01	2350	49 9	4440	< 0 1	< 0 02	< 0 1	12 0	< 0 04	< 0 5	301	< 3
TQ0166	Lettuce	3	washed	96 17	0 7	1 6	23400	55000	0 5	418	< 0 01	4330	75 9	4830	< 0 1	0 03	< 0 1	16 5	< 0 04	0 6	391	< 3
TQ0167	Lettuce	1	unwashed	95 15	1 5	7 2	23000	63600	0 7	388	0 11	582	65 9	4380	< 0 1	< 0 02	< 0 1	33 6	0 09	2 0	323	< 3
TQ0167	Lettuce	2	unwashed	96 42	1 5	2 6	32500	54500	0 6	389	0 10	650	61 9	4640	< 0 1	< 0 02	< 0 1	27 5	0 08	2 2	300	< 3
TQ0167	Lettuce	3	unwashed	97 26	1 9	1 9	27000	66100	0 7	336	0 12	569	88 2	5120	< 0 1	< 0 02	< 0 1	31 4	0 07	1 9	375	< 3
TQ0167	Lettuce	1	washed	95 88	1 1	1 5	28700	55300	< 0 2	292	< 0 01	584	61 3	4000	< 0 1	< 0 02	< 0 1	13 6	< 0 04	< 0 5	200	< 3
TQ0167	Lettuce	2	washed	97 70	1 0	0 8	37600	59100	< 0 2	251	< 0 01	479	59 1	4710	< 0 1	< 0 02	< 0 1	15 6	< 0 04	< 0 5	231	< 3
TQ0167	Lettuce	3	washed	96 71	1 5	1 8	27000	55900	0 4	286	< 0 01	596	72 9	4820	< 0 1	< 0 02	< 0 1	17 5	< 0 04	0 7	241	< 3
TQ0168	Lettuce	1	unwashed	95 29	1 3	2 2	17400	42200	0 9	363	0 08	854	42 1	4750	< 0 1	< 0 02	< 0 1	53 0	0 05	2 2	272	< 3
TQ0168	Lettuce	2	unwashed	95 62	1 4	1 9	18900	72600	1 0	239	0 09	830	42 2	4960	< 0 1	< 0 02	< 0 1	27 4	< 0 04	1 4	268	< 3
TQ0168	Lettuce	3	unwashed	96 12	1 7	2 4	20700	44100	1 2	393	0 10	983	48 9	5290	< 0 1	< 0 02	< 0 1	49 7	0 07	2 4	322	< 3
TQ0168	Lettuce	1	washed	95 51	1 4	1 1	13400	35000	0 6	282	< 0 01	987	49 4	4410	< 0 1	< 0 02	< 0 1	21 9	< 0 04	0 8	191	< 3
TQ0168	Lettuce	2	washed	95 98	1 1	1 5	18300	61300	0 7	232	< 0 01	761	43 9	4670	< 0 1	< 0 02	< 0 1	19 9	< 0 04	0 7	367	< 3
TQ0168	Lettuce	3	washed	95 56	1 0	0 8	20100	55600	0 7	320	< 0 01	1000	48 5	4440	< 0 1	< 0 02	< 0 1	19 1	< 0 04	0 7	375	< 3
TQ0169	Lettuce	1	unwashed	91 43	1 0	15 2	14400	35200	0 4	381	0 07	928	35 7	5560	< 0 1	< 0 02	< 0 1	34 0	0 35	2 0	275	< 3
TQ0169	Lettuce	2	unwashed	92 17	0 8	6 2	17100	71200	0 3	355	0 05	1260	33 3	5220	< 0 1	< 0 02	< 0 1	25 4	0 07	1 1	220	< 3
TQ0169	Lettuce	3	unwashed	91 85	1 1	5 5	14300	51900	0 3	373	0 06	923	39 8	5390	< 0 1	< 0 02	< 0 1	23 6	0 10	1 4	289	< 3
TQ0169	Lettuce	1	washed	92 92	0 6	5 2	10300	52800	< 0 2	235	< 0 01	529	32 9	4810	< 0 1	< 0 02	< 0 1	8 2	< 0 04	< 0 5	184	< 3
TQ0169	Lettuce	2	washed	92 84	0 7	2 2	16800	46000	< 0 2	247	< 0 01	915	33 9	4320	< 0 1	< 0 02	< 0 1	10 7	< 0 04	< 0 5	153	< 3
TQ0169	Lettuce	3	washed	92 59	0 8	4 2	15400	53700	< 0 2	321	< 0 01	1020	39 2	4990	< 0 1	< 0 02	< 0 1	14 2	< 0 04	0 5	213	< 3
TQ0170	Lettuce	1	unwashed	93 10	0 5	2 3	10600	36600	0 5	458	0 07	4040	42 8	3580	< 0 1	< 0 02	< 0 1	55 0	0 12	2 9	262	< 3
TQ0170	Lettuce	2	unwashed	93 72	0 5	2 9	12800	42100	0 6	582	0 07	5610	40 4	3890	< 0 1	< 0 02	< 0 1	61 4	0 14	3 6	255	< 3
TQ0170	Lettuce	3	unwashed	92 75	0 4	3 5	10200	33300	<0 2	461	0 05	3460	30 6	2770	< 0 1	< 0 02	< 0 1	50 9	0 10	2 5	194	< 3
TQ0170	Lettuce	1	washed	94 70	0 4	4 0	16200	40200	< 0 2	292	< 0 01	5490	41 3	3930	< 0 1	< 0 02	< 0 1	23 7	< 0 04	0 9	144	< 3
TQ0170	Lettuce	2	washed	93 82	0 4	2 9	12700	37200	< 0 2	251	< 0 01	3230	34 6	3560	< 0 1	< 0 02	< 0 1	18 1	< 0 04	0 7	146	< 3
TQ0170	Lettuce	3	washed	94 60	0 3	2 2	13900	47900	< 0 2	300	< 0 01	5900	49 9	3930	< 0 1	< 0 02	< 0 1	19 0	< 0 04	0 7	209	< 3
TQ0171	Lettuce	1	washed	93 82	0 8	0 6	12600	44500	< 0 2	290	< 0 01	2940	24 6	4030	< 0 1	< 0 02	< 0 1	15 5	< 0 04	0 6	155	< 3
TQ0171	Lettuce	2	washed	93 38	0 7	0 5	10800	57300	< 0 2	225	< 0 01	3080	26 0	3830	< 0 1	< 0 02	< 0 1	11 0	< 0 04	0 6	128	< 3
TQ0171	Lettuce	3	washed	93 77	0 8	0 7	12200	44300	< 0 2	249	< 0 01	2140	26 1	3970	< 0 1	< 0 02	< 0 1	15 4	< 0 04	0 6	127	< 3
TQ0172	Lettuce	1	unwashed	92 04	0 6	3 1	15300	55200	< 0 2	621	< 0 01	295	35 6	2430	< 0 1	< 0 02	< 0 1	80 9	0 16	4 6	100	< 3
TQ0172	Lettuce	2	unwashed	92 17	0 6	1 7	16700	35200	< 0 2	443	< 0 01	302	37 0	2460	< 0 1	< 0 02	< 0 1	37 9	0 06	2 4	80 5	< 3
TQ0172	Lettuce	3	unwashed	92 88	0 6	2 6	22200	46200	< 0 2	769	< 0 01	321	33 5	2920	< 0 1	< 0 02	< 0 1	69 3	0 13	3 9	110	< 3
TQ0172	Lettuce	1	washed	93 26	0 6	0 8	17200	49900	< 0 2	344	< 0 01	361	39 1	2430	< 0 1	< 0 02	< 0 1	27 9	< 0 04	1 0	63 3	< 3
TQ0172	Lettuce	2	washed	93 08	0 7	1 0	15000	46300	< 0 2	424	< 0 01	332	38 9	2590	< 0 1	< 0 02	< 0 1	34 3	< 0 04	1 4	75 4	< 3
TQ0172	Lettuce	3	washed	93 69	0 6	0 9	18100	71300	< 0 2	402	< 0 01	350	40 7	2590	< 0 1	< 0 02	< 0 1	26 5	< 0 04	1 0	75 0	< 3
TQ0173	Lettuce	1	unwashed	96 33	1 3	1 6	24500	33200	< 0 2	551	< 0 01	12800	45 2	3530	< 0 1	< 0 02	< 0 1	29 5	0 05	1 7	85 5	< 3
TQ0173	Lettuce	2	unwashed	95 53	0 8	1 0	19100	25000	< 0 2	330	< 0 01	10200	28 6	2460	< 0 1	< 0 02	< 0 1	19 4	< 0 04	0 9	65 7	< 3
TQ0173	Lettuce	3	unwashed	95 78	0 9	1 0	16600	49900	< 0 2	362	< 0 01	8620	32 8	2790	< 0 1	< 0 02	< 0 1	17 5	< 0 04	0 8	56 7	< 3
TQ0173	Lettuce	1	washed	95 81	1 2	0 3	19500	58900	< 0 2	286	< 0 01	9300	36 5	3350	< 0 1	< 0 02	< 0 1	7 1	< 0 04	< 0 5	61 4	< 3
TQ0173	Lettuce	2	washed	95 63	1 2	1 2	22200	61400	< 0 2	306	< 0 01	11100	35 3	3750	< 0 1	< 0 02	< 0 1	7 8	< 0 04	< 0 5	67 8	< 3
TQ0173	Lettuce	3	washed	95 67	1 2	0 4	20000	53900	< 0 2	238	< 0 01	6430	29 7	3030	< 0 1	< 0 02	< 0 1	7 6	< 0 04	< 0 5	71 6	< 3
TQ0174	Lettuce	1	unwashed	92 39	0 8	1 7	10000	37300	< 0 2	625	< 0 01	3170	43 4	4560	< 0 1	< 0 02	< 0 1	15 8	0 05	1 4	68 5	< 3
TQ0174	Lettuce	2	unwashed	92 06	0 6	1 4	12100	41100	< 0 2	538	< 0 01	1730	36 7	3950	< 0 1	< 0 02	< 0 1	13 5	< 0 04	1 0	57 8	< 3
TQ0174	Lettuce	3	unwashed	91 88	0 7	1 4	10600	22900	< 0 2	418	< 0 01	1780	34 4	3760	< 0 1	< 0 02	< 0 1	12 1	< 0 04	1 0	57 8	< 3
TQ0174	Lettuce	1	washed	93 10	0 5	0 9	11200	29400	< 0 2	268	< 0 01	2970	24 3	3620	< 0 1	< 0 02	< 0 1	3 7	< 0 04	< 0 5	48 9	< 3
TQ0174	Lettuce	2	washed	93 08	0 7	0 8	9750	26000	< 0 2	299	< 0 01	3500	33 2	4210	< 0 1	< 0 02	< 0 1	4 8	< 0 04	< 0 5	64 2	< 3
TQ0174	Lettuce	3	washed	92 99	0 6	0 8	11600	39700	< 0 2	358	< 0 01	3190	33 7	4180	< 0 1	< 0 02	< 0 1	5 4	< 0 04	< 0 5	63 0	< 3